HEATHKIT® MANUAL

for the

PORTABLE DIGITAL MULTIMETER

Model IM-2202

595-1573-07

HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATH COMPANY PHONE DIRECTORY

The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information	(616) 982-3411
Credit	(616) 982-3561
Replacement Parts	(616) 982-3571

Technical Assistance Phone Numbers

8:00 A.M. to 12 P.M. and 1:00 P.M. to 4:30 P.M., EST, Weekdays Only

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Amateur Radio	(616) 982-3296
Test Equipment, Weather Instruments and Home Clocks	(616) 982-3315
Television	(616) 982-3307
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[redacted]

YOUR HEATHKIT 90 DAY LIMITED WARRANTY

If you are not satisfied with our service - warranty or otherwise - or with our products, write directly to our Director of Customer Services, Heath Company, Benton Harbor, Michigan 49022. He will make certain your problems receive immediate, personal attention.

Our attorney, who happens to be quite a kitbuilder himself, insists that we describe our warranty using all the necessary legal phrases in order to comply with the new warranty regulations. Fine. Here they are:

For a period of ninety (90) days after purchase, Heath Company will replace or repair free of charge any parts that are defective either in materials or workmanship. You can obtain parts directly from Heath Company by writing us at the address below or by telephoning us at (616) 982-3571. And we'll pay shipping charges to get those parts to you — anywhere in the world.

We warrant that during the first ninety (90) days after purchase, our products, when correctly assembled, calibrated, adjusted and used in accordance with our printed instructions, will meet published specifications.

If a defective part or error in design has caused your Heathkit product to malfunction during the warranty period through no fault of yours, we will service it free upon proof of purchase and delivery at your expense to the Heath factory, any Heathkit Electronic Center (units of Schlumberger Products Corporation), or any of our authorized overseas distributors.

You will receive free consultation on any problem you might encounter in the assembly or use of your Heathkit product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

Our warranty does not cover and we are not responsible for damage caused by the use of corrosive solder, defective tools, incorrect assembly, misuse, fire, or by unauthorized modifications to or uses of our products for purposes other than as advertised. Our warranty does not include reimbursement for customer assembly or set-up time.

This warranty covers only Heathkit products and is not extended to allied equipment or components used in conjunction with our products. **We are not responsible for incidental or consequential damages.** Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

HEATH COMPANY
BENTON HARBOR, MI. 49022

Prices and specifications subject to change without notice.

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for the

PORTABLE DIGITAL MULTIMETER

Model IM-2202

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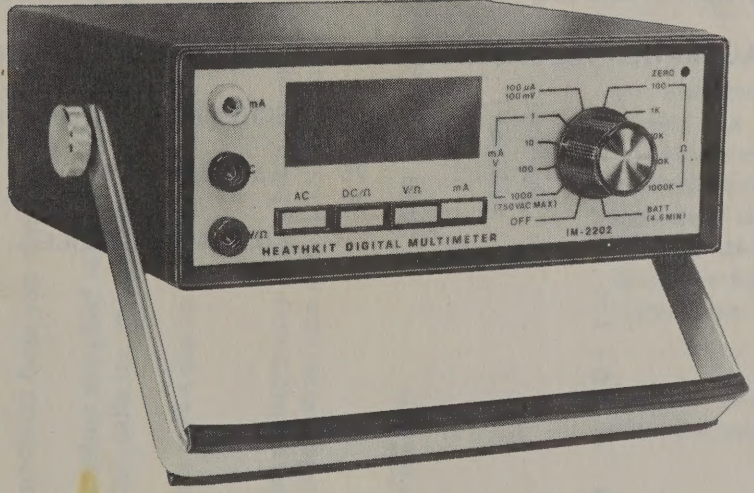

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

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TABLE OF CONTENTS

INTRODUCTION 3

UNPACKING 5

ASSEMBLY NOTES 6

LOGIC CIRCUIT BOARD
Parts List 9
Step-by-Step Assembly 15

DISPLAY CIRCUIT BOARD
Parts List 29
Step-by-Step Assembly 31

INPUT CIRCUIT BOARD
Parts List 37
Step-by-Step Assembly 41

GENERAL ASSEMBLY AND WIRING
Parts List 47
Step-by-Step Assembly
  Circuit Board Wiring 52
  Front Panel Assembly 62
  Chassis Assembly and Wiring 64
  Alternate Power Transformer Wiring 66

TEST LEAD AND CALIBRATION TOOL ASSEMBLY 73

INITIAL TESTS
Resistance Checks 75
Operational Check 76

CALIBRATION 77
Calibration with Built-in References 78
Calibration with Laboratory Standard References . . . 81

FINAL ASSEMBLY 85

OPERATION 87

IN CASE OF DIFFICULTY
General Troubleshooting Information 91
Troubleshooting Precautions 92
Troubleshooting Charts 93

OSCILLOSCOPE WAVEFORMS 107

SPECIFICATIONS 113

CIRCUIT DESCRIPTION 117

CIRCUIT BOARD X-RAY VIEWS 127

CIRCUIT BOARD VOLTAGE CHARTS 131

CHASSIS PHOTOGRAPHS 134

SEMICONDUCTOR IDENTIFICATION CHART 135

SCHEMATIC (fold-out from page) 137

WARRANTY . . . . Inside front cover

CUSTOMER SERVICE . . . . Inside rear cover

HEATH PARTS PRICE LIST
IM -2202 ECL 13 02/23/79

KEEP THIS PARTS LIST WITH YOUR MANUAL AND USE THE PRICES SHOWN BELOW WHEN ORDERING PARTS. THESE PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE.

THE PRICES SHOWN ON THE "HEATH PARTS PRICE LIST" APPLY ONLY ON PURCHASES FROM THE HEATH COMPANY WHERE SHIPMENT IS TO A U.S.A. DESTINATION. ADD 10% (MINIMUM 25 CENTS) TO THE PRICE WHEN ORDERING (MICHIGAN RESIDENTS ADD 4% SALES TAX) TO COVER INSURANCE, POSTAGE, AND HANDLING. OUTSIDE THE U.S.A., PARTS AND SERVICE ARE AVAILABLE FROM YOUR LOCAL HEATHKIT SOURCE AND WILL REFLECT ADDITIONAL TRANSPORTATION, TAXES, DUTIES, AND RATES OF EXCHANGE.

ADDITIONAL 3 FT ROLLS OF SOLDER, #331-6, CAN BE ORDERED FOR 25 CENTS EACH.

PART NUMBER	PRICE	PART NUMBER	PRICE	PART NUMBER	PRICE	PART NUMBER	PRICE
1- 88-12	.25	6-3010-12	.25	56- 89	.40	254- 33	.05
1- 144-12	.30	6-3011-12	.25	56- 90	.60	255- 63	.40
2- 27-12	1.00	6-3012-12	.25	56- 93	.60	255- 74	.10
2- 294	.65	6-4992-12	.25	57- 27	.60	259- 1	.05
2- 618-12	1.35	6-5119-12	.25	57- 42	.70	259- 30	.05
2- 726-12	1.35	6-5504-12	.50	57- 65	.40	260- 1	.20
3- 5- 3	1.90	6-6402-12	.30	57- 71	1.20	260- 65	.10
3- 6- 3	2.25	6-6571-12	.25	63- 693	14.10	261- 29	.15
3- 7- 3	2.55	6-7502-12	.30	64- 671	9.45	261- 34	.20
3- 14- 3	9.65	9- 60	12.20	70- 10	.30	266- 876	1.30
3- 24- 7	.50	10- 362	3.45	70- 11	.30	340- 8	.05@
6- 101-12	.25	10- 386	.75	73- 21	.15	340- 11	.10@
6- 102	.25	10- 936	.75	73- 45	.05	341- 1	.10@
6- 103-12	.25	10-1086	1.50	75- 179	.70	341- 2	.10@
6- 104	.25	11- 133	3.55	75- 191	.15	343- 15	.10
6- 104-12	.25	11- 149	5.70	75- 718	.45	344- 2	.10@
6- 105-12	.25	20- 76	.40	85-1375- 1	3.60	344- 3	.10@
6- 150	.25	20- 103	.40	85-1911- 2	7.15	344- 32	.05@
6- 152-12	.25	20- 106	.75	85-1923- 2	9.45	344- 59	.05@
6- 181-12	.25	20- 115	.55	89- 51	3.75	346- 26	.25
6- 183-12	.25	20- 127	1.00	90- 605- 1	4.05	390-1083	.25
6- 223-12	.25	20- 167	.70	90- 606- 1	3.75	411- 294	6.25
6- 224-12	.25	20- 181	1.25	100-1631- 1	2.10	411- 295	7.00
6- 242-12	.25	21- 31	.30	100-1735	******	417- 67	.50
6- 332-12	.25	21- 33	.25	134- 871	7.35	417- 140	1.50
6- 333-12	.25	21- 61	.30	204-1933	1.15	417- 191	3.25
6- 391	.25	21- 122	.55	205- 778	.35	417- 201	.55
6- 393-12	.25	21- 140	.25	206-1141	1.45	417- 234	.60
6- 472-12	.25	21- 144	.45	210- 89	3.95	417- 242	.85
6- 473	.25	21- 168	.30	211- 59	1.60	417- 261	3.85
6- 474-12	.25	21- 176	.30	211- 63	2.45	417- 294	.65
6- 513	.25	21- 181	.30	214- 66	1.15	417- 295	.70
6- 561-12	.25	21- 184	.25	250- 56	.05	417- 801	.45
6- 562-12	.25	25- 180	1.60	250- 381	.05	417- 819	1.50
6- 680	.25	25- 200	.75	250- 452	.10	418- 29	6.15
6- 682-12	.25	25- 221	.70	250- 527	1.20	421- 2	.20
6- 683	.25	25- 223	1.60	250-1109	.05	421- 26	.50
6-1002-12	.30	25- 230	2.85	252- 3	.05	421- 27	.70
6-1103-12	.25	25- 252	.75	252- 7	.05	421- 38	1.20
6-1432-12	.25	25- 253	.75	252- 69	.10	422- 1	.65
6-1782-12	.25	27- 43	.55	252- 90	.10	431- 55	.15
6-1804-12	1.05	27- 85	.50	252- 101	.20	432- 76	.90
6-1901-12	.25	27- 90	3.25	253- 8	.10	432- 134	.03
6-1902-12	.25	27- 133	.50	253- 16	.10	434- 221	.90
6-1903-12	.25	31- 63	2.45	253- 85	.05	434- 230	.40
6-2001-12	.25	31- 67	2.50	253- 86	.10	436- 11	.20
6-2002-12	.30	40-1019	1.20	253- 119	.05	436- 22	.20
6-2501-12	.25	54- 842	6.15	254- 1	.05	436- 24	.20
6-2502-12	.30	54- 942	3.60	254- 5	.05	438- 47	.35
6-2731-12	.25	56- 56	.55	254- 15	.05	439- 7	.40

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ADDITIONAL 3 FT ROLLS OF SOLDER, #331-6, CAN BE ORDERED FOR 25 CENTS EACH.

PART NUMBER	PRICE	PART NUMBER	PRICE	PART NUMBER	PRICE	PART NUMBER	PRICE
439- 9	.30						
442- 39	1.45						
442- 66	2.90						
443- 626	15.75						
446- 618	5.40						
455- 50	.15						
462- 264	1.05						
490- 5	.25						
490- 111	.15						

***** WRITE HEATH COMPANY FOR PRICE INFORMATION.
@ PRICE PER FOOT.

HEATH
Schlumberger

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

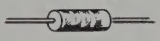
IMPORTANT INFORMATION regarding the resistors in your kit.

Carbon film resistors have been supplied with your kit in place of many of the carbon composition resistors previously used. Although carbon composition resistors may still be illustrated in your Manual, the values, color codes and installation of these components remain the same.

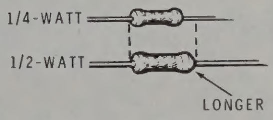
However, there are three important facts you should remember:

1. **All carbon film resistors supplied with your kit have a tolerance of 5%.** You can use them in any assembly step which calls for 5% or 10% tolerance resistors.
2. Carbon film resistors have a greater heat dissipating ability for their physical size than carbon composition resistors.
3. **1/2-watt carbon film resistors may nearly be the same physical size as 1/4-watt carbon film resistors.** However, side-by-side comparison will identify the larger wattage resistor as having the slightly longer body length.

composition



film



Thank you,

HEATH COMPANY

HEATHKIT P-0

GENERAL
591-2361

INTRODUCTION

The Heathkit Model IM-2202 Portable Digital Multimeter is a battery-operated instrument designed for both field and laboratory use. Four rechargeable, nickel-cadmium batteries, included with your kit, typically provide eight hours of field operation per charge. The charging circuit is built in for convenience. The Multimeter may also be operated continuously from line voltage, and dual primary windings in the power transformer permit you to wire the meter for either 120 or 240 volts AC.

When the Multimeter is calibrated with laboratory standards, the DC accuracy is ±0.2% and the AC accuracy is ±.75% up to 10 kHz. Built-in references enable you to calibrate the Multimeter to an accuracy of typically ±0.5% for DC and ±1.5% for AC.

The 3-1/2-digit display features large, easy-to-read numbers, automatic polarity indication, and automatic decimal point placement. All circuitry is solid-state except for the display tubes. A MOS/LSI* integrated circuit contains all of the digital counting and logic circuits. This integrated circuit is the heart of a dual-slope analog-to-digital converter which provides extremely stable, accurate performance under all conditions of specified temperature and battery charge.

Measurement functions include AC and DC voltages, AC and DC current, Resistance, and a "Battery Test" position. All functions are protected from overvoltages, by fuses or diodes, up to 250 VAC. Voltage and current inputs are separated to protect the circuitry being tested.

The Multimeter features a continuous-rotation range switch and a 4-position function switch for ease of operation. The voltage ranges are 100 mV full-scale to 1000 volts full-scale and have a high input resistance (10 MΩ typical). All voltage ranges, except the 1000-volt range, have 100% overrange capabilities. The current ranges are 100 μA full-scale to 1000 mA full-scale, with 100% overrange capability, and feature low-voltage drop (100 mV typical). Resistance ranges include 100 Ω full-scale to 1 MΩ full-scale with 100% overrange.

This compact, lightweight instrument is housed in a low-profile, attractive cabinet that features a carrying handle. You can also use the handle to support the front of the instrument at a more convenient viewing angle. A wiring harness and plug-in components are used to simplify construction and servicing. The IM-2202 is designed to provide long, reliable performance for the kit builder, lab technician, or professional serviceman.

Refer to the "Kit Builders Guide" for information on tools, wiring, soldering, resistors, and capacitors.

---

*Metal-oxide semiconductor/large-scale integration

UNPACKING

Your Multimeter is packed in a shipping carton which contains a smaller carton marked "Packs 1 through 3." Inside the smaller carton is a Pack Index Sheet that shows which compartment contains the parts for each pack. All the remaining parts in the shipping carton will be referred to as a "final pack."

Each assembly section of the Manual contains a parts list and step-by-step instructions. At the beginning of each parts list, you will be instructed which numbered pack to open. You will also be directed to remove any parts from the final pack that are required to complete that assembly section. Disregard any numbers that are not listed in the parts list when more than one number is on any package or part in this kit.

NOTE: To avoid intermixing parts, do not open any of the packages until instructed to do so at the beginning of a parts list. Any part that is packaged in an individual envelope with a part number on it should be placed back in the envelope after it is identified, until it is called for in a step.

ASSEMBLY NOTES

Resistors are designated by the resistance value and color code. The symbol "Ω" means ohms (K = 1,000; M = 1,000,000). Capacitors are designated by their value and type. The symbol "μF" means microfarad, and "pF" means picofarad. 1 μF is equal to 1,000,000 pF.

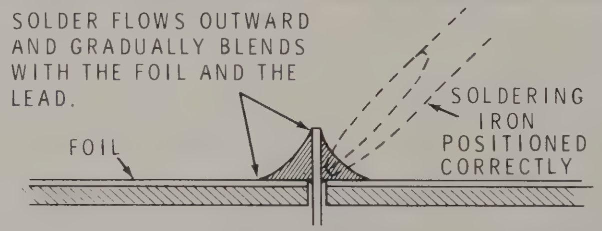
Parts will be installed on the top (the side with the component outlines) of the circuit board, and the leads will be soldered to the foil on the other side. Some circuit boards have foil on both sides. However, never solder leads to the foil on the top side unless you are specifically instructed to do so in a step.

Only a portion of the circuit board is shown in each of the following Pictorials. A small drawing at the top of each Pictorial shows the area of the circuit board to be assembled.

Due to the small foil area around the circuit board holes and the small areas between foils, you should use the utmost care to prevent solder bridges (see Page 7) between adjacent foil areas. Use a minimum amount of solder and do not heat components excessively. Diodes, transistors, and IC's can be damaged if subjected to excessive amounts of heat.

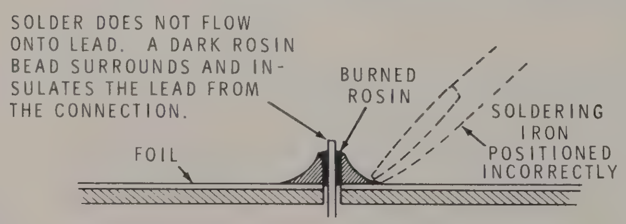
The first illustration below shows how to make a good solder connection. The illustrations at the bottom of the page show how bad solder connections can occur. On Page 7 are some examples of bad solder connections and solder bridges, and how to correct them. Make sure you read all of the soldering information before you begin to assemble your kit.

A GOOD SOLDER CONNECTION

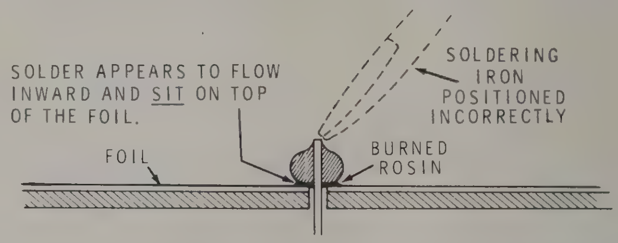

SOLDER FLOWS OUTWARD AND GRADUALLY BLENDS WITH THE FOIL AND THE LEAD.
FOIL
SOLDERING IRON POSITIONED CORRECTLY

Heat both the lead and the circuit board foil at the same time. The solder will flow onto the lead and the foil evenly and will then make a good electrical connection between the lead and the foil.

BAD SOLDER CONNECTIONS


SOLDER DOES NOT FLOW ONTO LEAD. A DARK ROSIN BEAD SURROUNDS AND INSULATES THE LEAD FROM THE CONNECTION.
BURNED ROSIN
SOLDERING IRON POSITIONED INCORRECTLY
FOIL

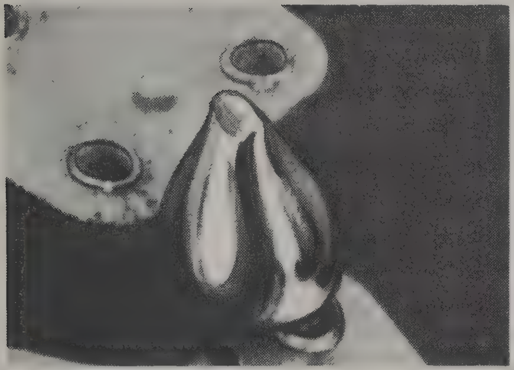
When the lead is not heated sufficiently, the solder will not flow onto the lead as shown above. Reheat the connection and, if necessary, apply a small amount of additional solder to obtain a connection as shown under "A Good Solder Connection."


SOLDER APPEARS TO FLOW INWARD AND SIT ON TOP OF THE FOIL.
SOLDERING IRON POSITIONED INCORRECTLY
FOIL
BURNED ROSIN

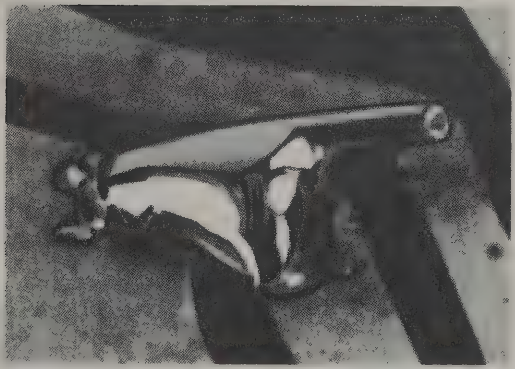
When the foil is not heated sufficiently, the solder will blob on the circuit board as shown above. Reheat the connection and, if necessary, apply a small amount of additional solder to obtain a connection as shown under "A Good Solder Connection."

SOLDER CONNECTIONS TO WATCH OUT FOR

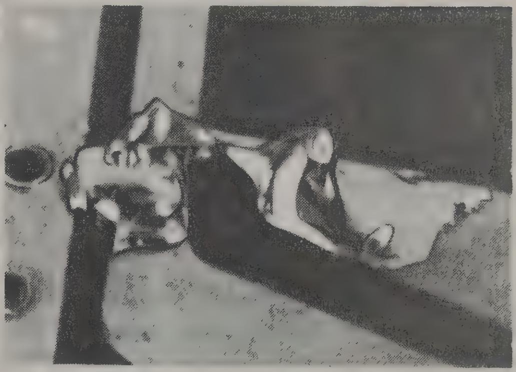
The following photographs show examples of the types of bad solder connections that are the most common cause of trouble. If you locate any of these bad solder connections in your kit, correct them as instructed.



In this case, the solder was applied to the lead but did not flow onto the foil. To correct, reheat the connection.



Here, solder has flowed along a lead and bridged to another foil. To correct, hold the circuit board above the soldering iron and reheat the solder. As the solder melts, it will flow down the iron. Then cut off the excess lead length. PROTECT YOUR EYES.



Here, hot solder has been dropped onto the foil and the solder connected or bridged (or crossed) three foils. To correct, hold the circuit board above the soldering iron and reheat the solder. As the solder melts, it will flow down the iron. PROTECT YOUR EYES.

NOTE: Solder that bridges two connections on the SAME FOIL is alright and does not need to be corrected.

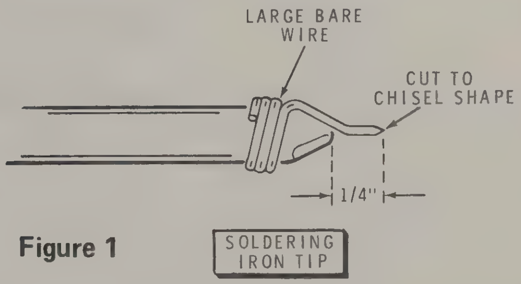


Figure 1

NOTE: For soldering in difficult areas, proceed as follows: Be sure your soldering iron is cool. Then wrap the large bare wire supplied with this kit, tightly around the soldering iron tip as shown in Figure 1. Allow approximately 1/4" of wire to extend beyond the end of the soldering iron. Cut the wire end to a chisel shape as shown. Then turn the soldering iron on and melt a small amount of solder around the bare wire. This will improve heat transfer from the soldering iron tip to the wire. You may have to retighten the wire wrap occasionally, since it will loosen after it has been heated for some time.

LOGIC CIRCUIT BOARD

PARTS LIST

Unpack the parts from Pack #1 and check each part against the following list. Make a check (✓) in the space provided as you identify each part. Do not throw away any packing materials until all parts are accounted for.

To order a replacement part, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of the Manual. For pricing information, refer to the separate "Heath Parts Price List."

Each circuit part in this kit has its own component number (R2, C4, etc.). Use these numbers when you want to positively identify the same part in the various sections of the Manual. These numbers, which are especially useful if a part has to be replaced, appear:

- In the Parts List.
- At the beginning of each step where a component is installed.
- In some illustrations.
- In the sections at the rear of the Manual.
- In the Schematic.

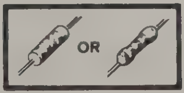
RESISTORS

All 5% and 10% tolerance resistors have four color bands (last band gold for 5% and silver for 10%). The last band (gold or silver) will not be called out.

NOTE: Resistors may be packed in more than one envelope. Open all resistor envelopes in this pack before you check the resistors against the Parts List.

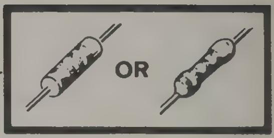
1/4-Watt, 5% and 10%

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	100 Ω (brown-black-brown)	1-60-12	R302
( )	2	180 Ω (brown-gray-brown)	1-61-12	R298,R299
( )	2	560 Ω (green-blue-brown)	1-66-12	R297, R301
( )	8	1500 Ω (brown-green-red)	1-71-12	R226,R231, R235,R239, R244,R248, R253,R291



Resistors (cont'd.)

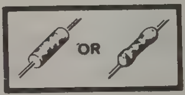
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	2	2400 Ω (red-yellow-red)	1-97-12	R275, R285
( )	10	4700 Ω (yellow-violet-red)	1-76-12	R207, R209, R212, R214, R216, R218, R221, R223, R267, R272
( )	4	6800 Ω (blue-gray-red)	1-78-1	R266, R268, R269, R281
( )	6	10 kΩ (brown-black-orange)	1-80-12	R206, R211, R215, R219, R271, R273
( )	7	18 kΩ (brown-gray-orange)	1-94-12	R224, R228, R233, R237, R242, R246, R251
( )	9	22 kΩ (red-red-orange)	1-91-12	R225, R229, R234, R238, R243, R247, R303
( )	1	33 kΩ (orange-orange-orange)	1-82-12	R276
( )	2	39 kΩ (orange-white-orange)	1-29-12	R283, R284
( )	6	220 kΩ (red-red-yellow)	1-85-12	R208, R213, R217, R222, R255, R256
( )	7	470 kΩ (yellow-violet-yellow)	1-18-12	R227, R232, R236, R241, R245, R249, R254



1/4-Watt, 1%

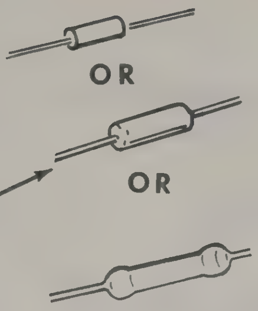
All 1% color coded resistors have five color bands (last band brown). This last band is set apart from the other bands. The last band (brown) will not be called out.

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	51.1 Ω (green-brown-brown-white)	6-5119-12	R259
( )	1	2500 Ω (red-green-black-brown)	6-2501-12	R263
( )	1	2730 Ω (red-violet-orange-brown)	6-2731-12	R205
( )	2	14.3 kΩ (brown-yellow-orange-red)	6-1432-12	R278, R286
( )	1	20 kΩ (red-black-black-red)	6-2002-12	R261
( )	1	25 kΩ (red-green-black-red)	6-2502-12	R265
( )	2	49.9 kΩ (yellow-white-white-red)	6-4992-12	R203, R258
( )	1	110 kΩ (brown-brown-black-orange)	6-1103-12	R264
( )	1	5.5 MΩ (green-green-black-yellow)	6-5504-12	R201



1/2-Watt, 5% and 10%

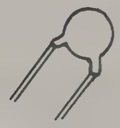
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	15 Ω (brown-green-black)	1-54	R292
( )	1	68 Ω (blue-gray-black)	1-53	R304
( )	1	1000 Ω (brown-black-red)	1-172	R279
( )	2	51 kΩ (green-brown-orange)	1-65	R204, R282
( )	1	68 kΩ, 10% (blue-gray-orange)	1-60	R288



CAPACITORS

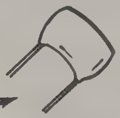
Disc

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	4	.001 μF	21-140	C201,C202, C203,C204
( )	5	.01 μF	21-176	C206,C216, C219,C223, C224
( )	3	.02 μF	21-31	C225,C229, C231
( )	1	750 pF	21-184	C222



Mica

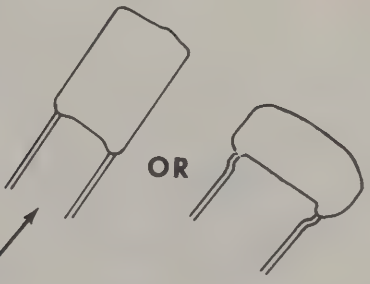
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	68 pF	20-76	C214
( )	1	300 pF	20-115	C207
( )	1	620 pF	20-167	C208
( )	1	1300 pF	20-127	C209
( )	1	2200 pF	20-181	C211



Mylar*

NOTE: Mylar capacitors can be marked three different ways. EXAMPLE: .1, .1k, or .1 μF. However, the Parts List and installation instructions will always use μF.

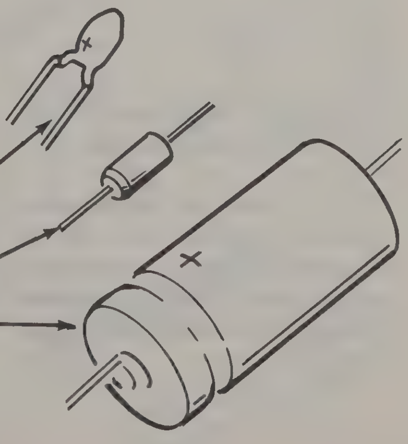
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	.047 μF Mylar	27-43	C205
( )	1	.22 μF Mylar	27-85	C212
( )	2	2.2 μF Mylar	27-90	C215, C226



OTHER

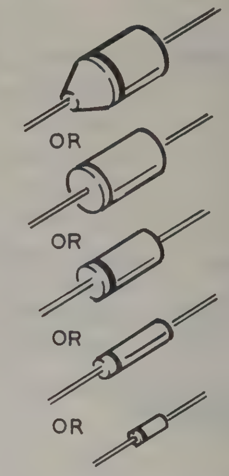
NOTE: Tantalum capacitors can be marked three different ways. EXAMPLE: 47, 47M, or 47k. However, the Parts List and installation instructions will always use μF.

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	.68 μF tantalum	25-200	C213
( )	4	47 μF tantalum	25-223	C218, C221, C232, C233
( )	2	2.2 μF tantalum	25-180	C227, C228
( )	1	2000 μF electrolytic	25-230	C217



*DuPont Registered Trademark

NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.



DIODES

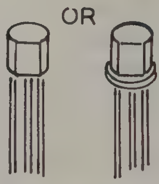
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	1N4149	56-56	D202
( )	6	1N2071	57-27	D206,D207, D208,D209, D215,D216
( )	5	1N4002	57-65	D205,D211, D212,D213, D214
( )	3	Selected zener	417-242	D201,D203, D204

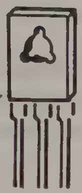
TRANSISTORS-INTEGRATED CIRCUITS

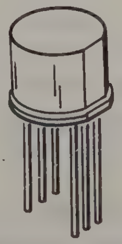
NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways.

1. Part number.
2. Type number.
3. Part number and type number.
4. Part number with a type number other than the one listed.

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	2	2N2712 transistor	417-67	Q218, Q219
( )	1	X29A829 transistor	417-201	Q227
( )	1	2N3638A transistor	417-234	Q229
( )	11	MPSA42 transistor	417-294	Q202, Q204, Q206, Q208, Q211, Q212, Q213, Q214, Q215, Q216, Q217
( )	4	MPSL51 transistor	417-295	Q203, Q205, Q207, Q209
( )	7	MPSA20 transistor	417-801	Q221, Q222, Q223, Q224, Q226, Q233, Q234
( )	2	MJE171 transistor	417-819	Q231, Q232
( )	1	TD101 transistor	417-191	Q228
( )	2	TD401 transistor	417-261	Q201,Q225



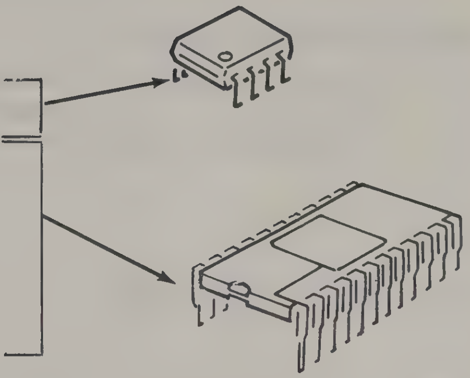




NOTE: If either the part number or the "Description" number is on an integrated circuit, you have the correct part. Do not be concerned about any other numbers. On integrated circuits, the description number may have additional leters or numbers other than those given in the list. Example: SN(7490)N or MC(7490)P.

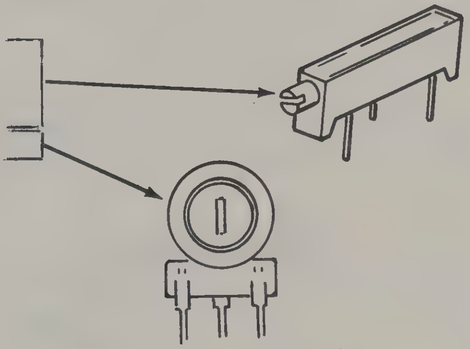
TRANSISTORS-INTEGRATED CIRCUITS (cont'd.)

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	308 integrated circuit	442-66	IC202
( )	1	6013 integrated circuit. NOTE: Do not open the case containing the integrated circuit at this time.	443-626	IC201



CONTROLS

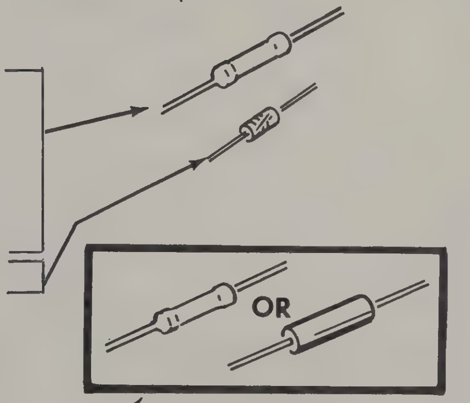
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	3	5000 Ω (5k)	11-133	R262, R277, R287
( )	1	50 kΩ	11-149	R257
( )	2	20 kΩ	10-1086	R202, R289

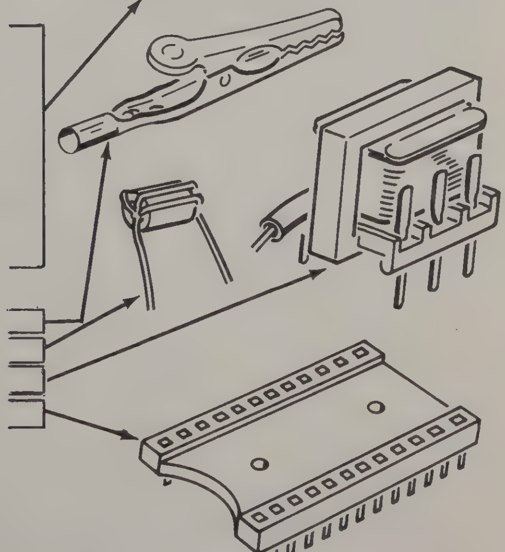


MISCELLANEOUS

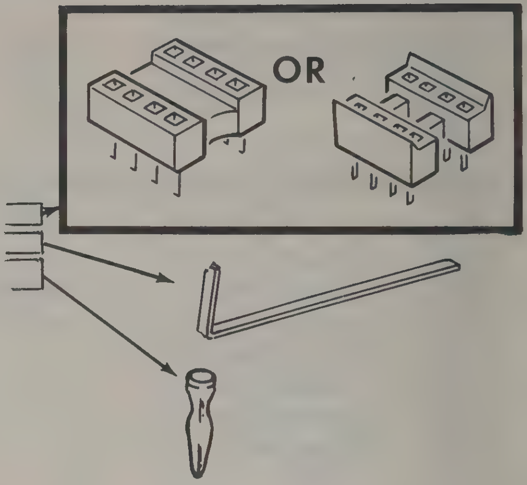
NOTE: There are two checkoff spaces (✓) for each item in the following list since there are two envelopes that contain identical parts. After you identify each part, make sure you place it back in the same envelope.

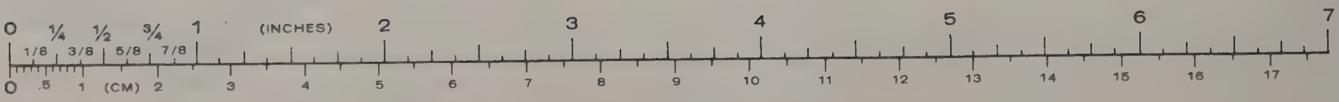
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
	2	Calibration voltage envelopes, each containing:	100-1631	
) ( )	*1*	*2000 Ω 1% (red-black-black-brown) resistor*		R307,R308
) ( )	*1*	*17.8 kΩ, 1% (brown-violet-gray-red) resistor*		R306,R309
) ( )	*1*	*110 kΩ, 1% (brown-brown-black-orange) resistor*		R305,R311
) ( )	*1*	*Zener diode*		D217,D218
	1	Standard Resistance Package containing:	100-1735	
( )	*1*	*1900 Ω, 1% (brown-white-black-brown) resistor*		R293
( )	*1*	*19 kΩ, 1% (brown-white-black-red) resistor*		R294
( )	*1*	*190 kΩ, 1% (brown-white-black-orange) resistor*		R295
( )	*1*	*1.8 MΩ, 1% (brown-gray-black-yellow) resistor*		R296
( )	1	Alligator clip	260-1	
( )	1	23 μH coil	40-1019	L201
( )	1	Converter transformer	54-942	T201
( )	1	Large IC socket	434-221	





	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
MISCELLANEOUS (cont'd.)				
( )	1	Small IC socket	434-230	
( )	1	IC puller	490-111	
( )	63	Connector pins (5 extra)	432-134	
PARTS NEEDED FROM FINAL PACK				
( )	1	6" large bare wire	340-11	
( )	1	Logic circuit board	85-1923-2	
		Manual (See front cover for part number.)		
( )	1	Parts Order Form	597-260	
( )	1	Kit Builders Guide	597-308	
		Solder		





STEP-BY-STEP ASSEMBLY

START

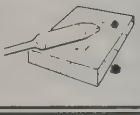
NOTE: As you assemble the circuit board, use only 1/4-watt, 5% or 10% resistors unless other resistors (1/2-watt or 1/4-watt, 1%) are called for in the steps.

Position the logic circuit board as shown. Then perform the following steps.

Install seven 470 kΩ (yellow-violet-yellow) resistors at:

( ) R249.
( ) R245.
( ) R236.
( ) R254.
( ) R232.
( ) R241.
( ) R227.

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...
WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.

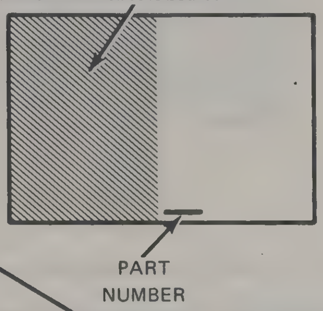


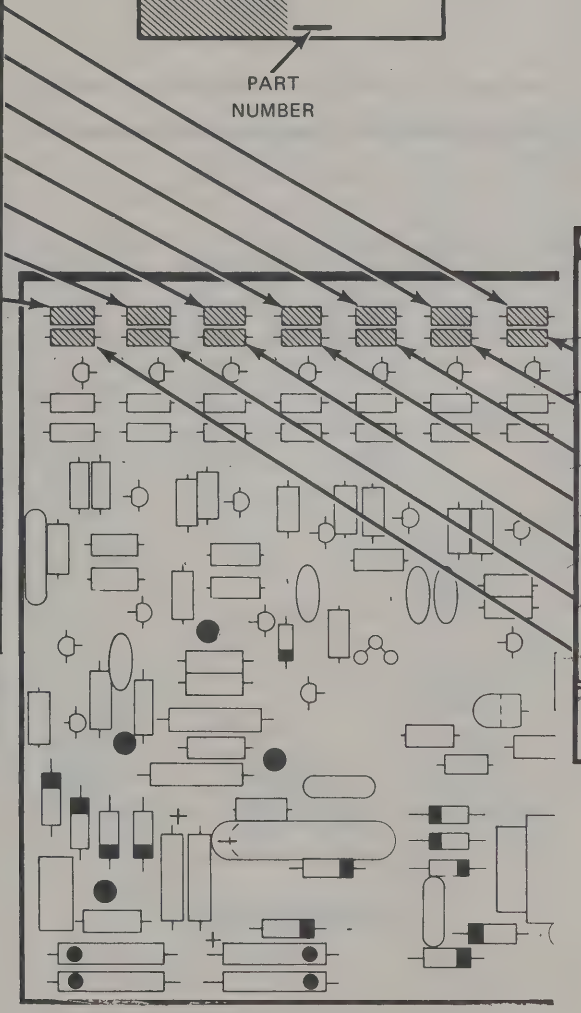
SAFETY WARNING: Avoid eye injury when you clip off excess leads. Hold the leads so they can not fly toward your eyes.

( ) Solder the leads to the foil and cut off the excess lead lengths.

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.





PICTORIAL 1-1

CONTINUE

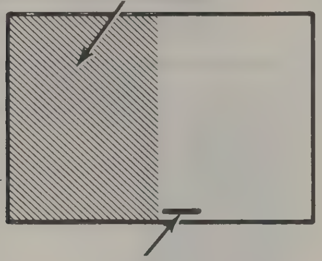
Install seven 1500 Ω (brown-green-red) resistors at:

( ) R248.
( ) R244.
( ) R235.
( ) R253.
( ) R231.
( ) R239.
( ) R226.

( ) Solder the leads to the foil and cut off the excess lead lengths.

IDENTIFICATION
DRAWING

The steps performed in this Pictorial are in this area of the circuit board.



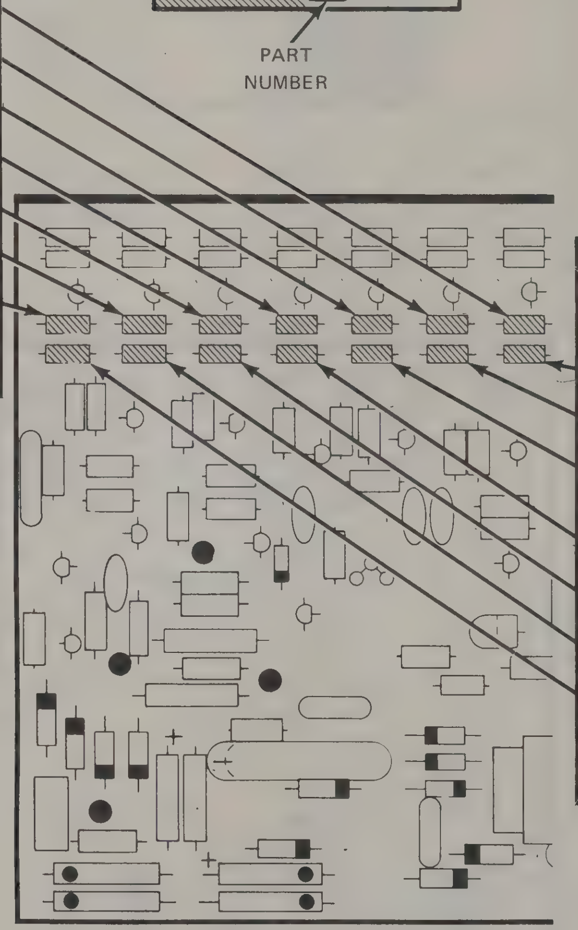
PART
NUMBER

START

Install seven 22 kΩ (red-red-orange) resistors at:

(✓) R247. . . . .
(✓) R243. . . . .
(✓) R234. . . . .
(✓) R252. . . . .
(✓) R229. . . . .
(✓) R238. . . . .
(✓) R225. . . . .

(✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

Install seven 18 kΩ (brown-gray-orange) resistors at:

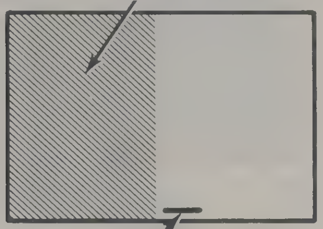
(✓) R246.
(✓) R242.
(✓) R233.
(✓) R251.
(✓) R228.
(✓) R237.
(✓) R224.

(✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-2

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.



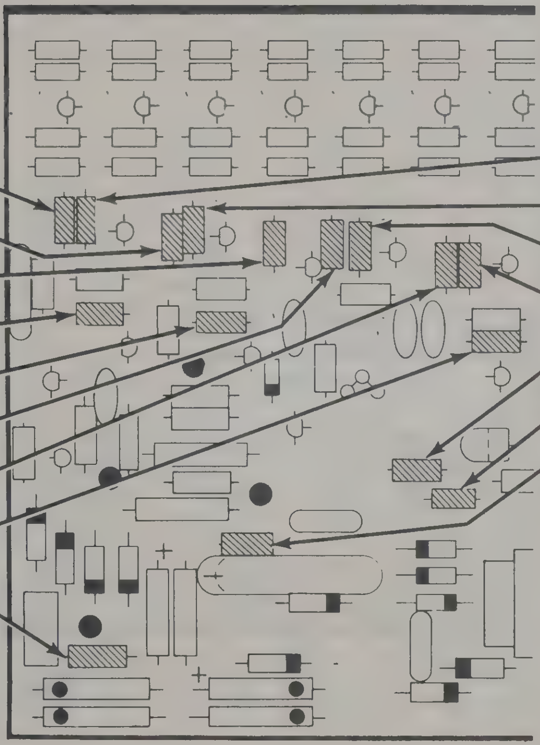
START

Install eight 4700 Ω (yellow-violet-red) resistors at:

- (●) R207. . . . .
- (●) R212. . . . .
- (●) R216. . . . .
- (●) R209. . . . .
- (●) R214. . . . .
- (●) R218. . . . .
- (●) R221. . . . .
- (●) R223. . . . .

(●) R288: 68 kΩ, 1/2-watt (blue-gray-orange).

(●) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

Install four 10 kΩ (brown-black-orange) resistors at:

- (●) R206.
- (●) R211.
- (●) R215.
- (●) R219.

(●) R275: 2400 Ω (red-yellow-red).

(●) R274: 22 kΩ (red-red-orange).

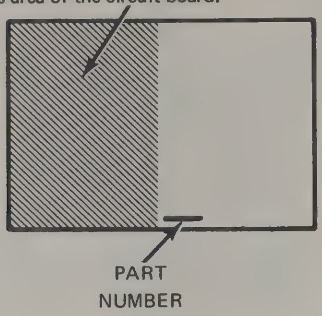
(●) R302: 100 Ω (brown-black-brown).

(●) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-3

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.



START

Install six 220 kΩ (red-red-yellow) resistors at:

(•) R222.

(•) R217.

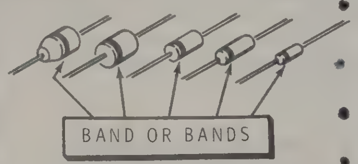
(•) R213.

(•) R255.

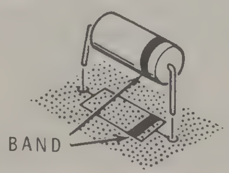
(•) R208.

(•) R256.

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES.



When you install diodes, always position the banded end as shown on the circuit board.



Install five 1N4002 diodes (#57-65) at:

(•) D211.

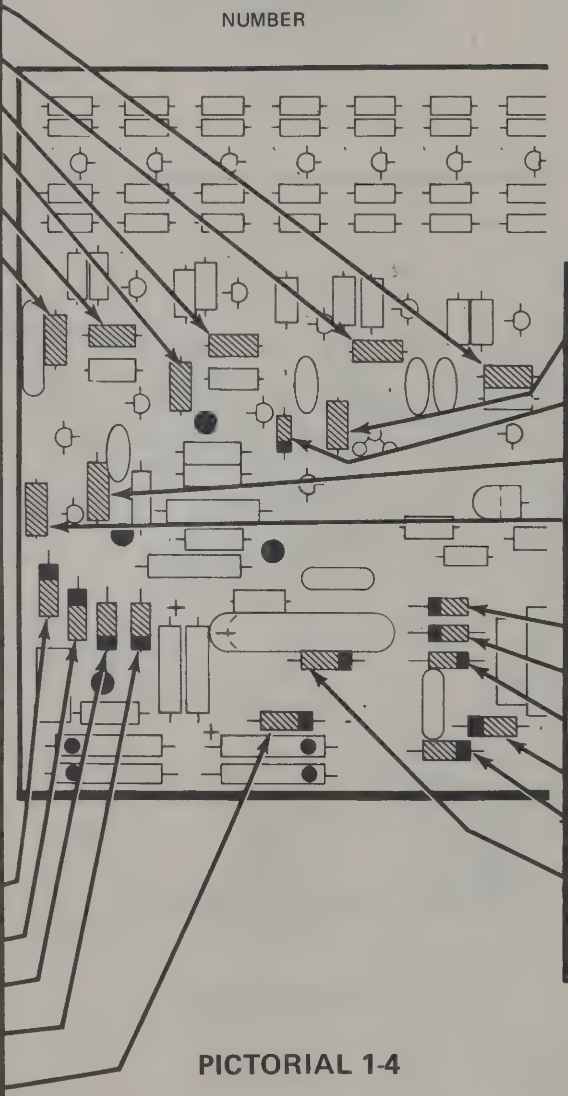
(•) D213.

(•) D214.

(•) D212.

(•) D205.

(•) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

(•) R276: 33 kΩ (orange-orange-orange).

(•) D202: 1N4149 diode (#56-56).

(•) R304: 68 Ω, 1/2-watt (blue-gray-black).

(•) R303: 22 kΩ (red-red-orange).

Install six 1N2071 diodes (#57-27) at:

(•) D206.

(•) D208.

(•) D209.

(•) D216.

(•) D215.

(•) D207.

(•) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-4

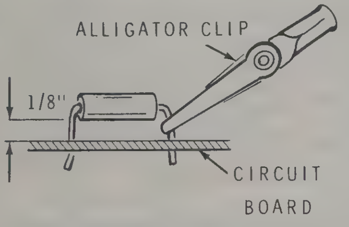
START

( ) Locate one of the envelopes marked "100-1631 Calibration Voltage." Mark this envelope with a plus (+) sign so you can identify it later.

( ) Remove the three resistors from the envelope and set the envelope aside. Do not remove the diode until it is called for in a later step.

NOTE: In the following steps, the three resistors from the calibration envelope will be spaced approximately 1/8" above the circuit board and the alligator clip will be used as a "heat sink" to protect these resistors from excessive heat. Use the following procedure to install each resistor.

1. Bend the leads of the resistor and clip the alligator clip on one lead.
2. Install the resistor at the location called out in the step. Then turn the circuit board over and solder the lead that has the alligator clip attached to the foil.



3. Allow at least ten seconds for the solder connection to cool. Then, remove the alligator clip and clip it on the other lead and solder this lead to the foil.
4. Again, wait at least ten seconds before you remove the alligator clip. Then cut off the excess lead lengths on the foil side of the circuit board.

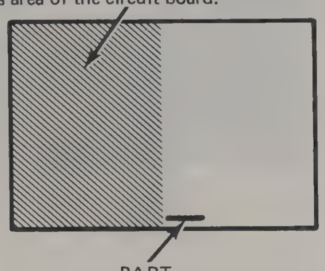
(●) R307: 2000 Ω, 1% (red-black-black-brown).

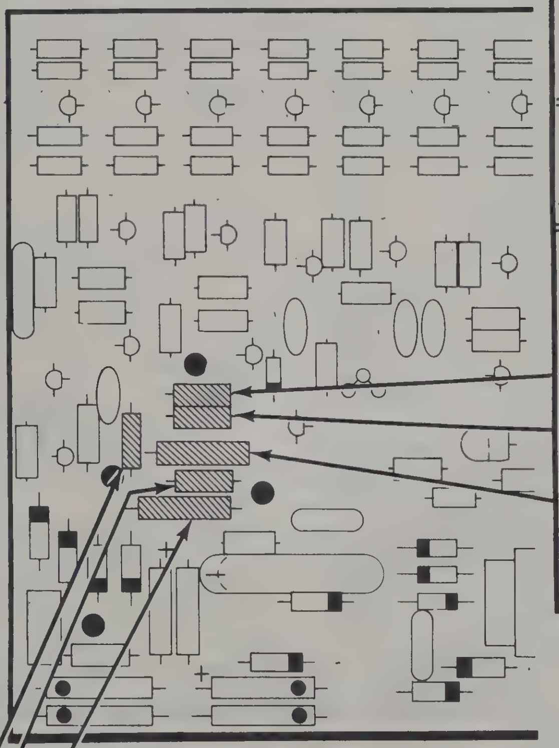
(●) R306: 17.8 kΩ, 1% (brown-violet-gray-red).

(●) R305: 110 kΩ, 1% (brown-brown-black-orange).

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.





PICTORIAL 1-5

CONTINUE

( ) Locate the other envelope marked "100-1631 Calibration Voltage." Mark this envelope with a minus (–) sign so you can identify it later.

( ) Remove the three resistors from the envelope and set the envelope aside. Do not remove the diode until it is called for in a later step.

As before, install the three resistors in the following steps, approximately 1/8" above the circuit board, with the alligator clip as a heat sink.

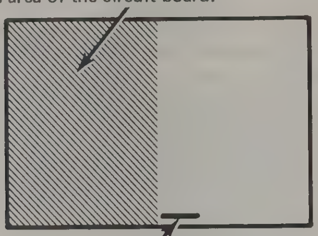
(●) R308: 2000 Ω, 1% (red-black-black-brown).

(●) R309: 17.8 kΩ, 1% (brown-violet-gray-red).

(●) R311: 110 kΩ, 1% (brown-brown-black-orange). NOTE: Solder the lead nearest this step to both the foil and component sides of the circuit board.

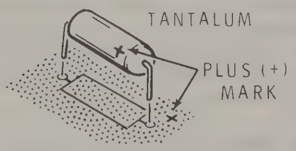
IDENTIFICATION
DRAWING

The steps performed in this Pictorial are in this area of the circuit board.



START

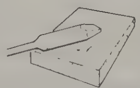
NOTE: When you install tantalum capacitors, always place the plus (+) marked lead on the capacitor in the plus (+) marked hole on the circuit board.



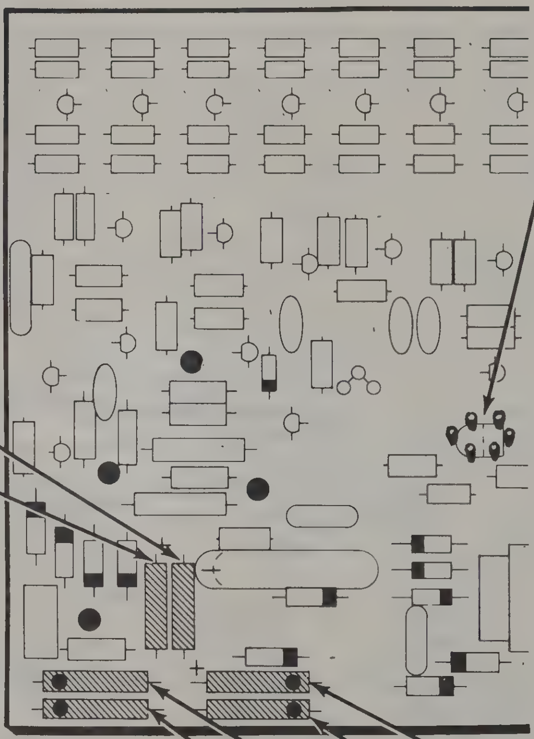
(●) C228: 2.2 μF tantalum.

(●) C227: 2.2 μF tantalum.

FOR GOOD SOLDER CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...
WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



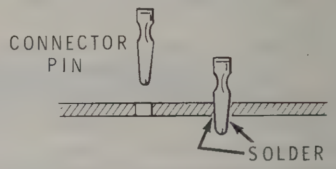
( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

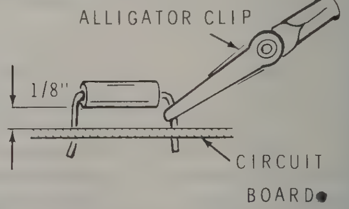
NOTE: Five extra connector pins have been supplied with your kit. If any connector pin becomes damaged or filled with solder in the following steps, replace it with one of the extras.

( ) Install six connector pins at Q225A/Q225B as shown. Solder each pin as you install it.



( ) Locate the envelope marked "100-1735 Standard Resistance Package" and remove the four resistors. IMPORTANT: Save the envelope. You will use the figures recorded on it later to calibrate your multimeter.

NOTE: In the following steps, install the four resistors approximately 1/8" above the circuit board and use the alligator clip as a heat sink.



(●) R293: 1900 Ω, 1% (brown-white-black-brown).

(●) R294: 19 kΩ, 1% (brown-white-black-red).

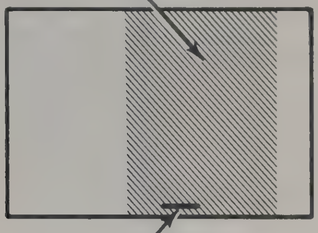
(●) R296: 1.8 MΩ, 1% (brown-gray-black-yellow).

(●) R295: 190 kΩ, 1% (brown-white-black-orange).

PICTORIAL 1-6

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.



START

(✓) R272: 4700 Ω (yellow-violet-red).

(✓) R271: 10 kΩ (brown-black-orange).

(✓) R273: 10 kΩ (brown-black-orange).

(✓) R269: 6800 Ω (blue-gray-red).

(✓) R286: 14.3 kΩ, 1% (brown-yellow-orange-red).

(✓) R283: 39 kΩ (orange-white-orange).

(✓) R284: 39 kΩ (orange-white-orange).

(✓) R285: 2400 Ω (red-yellow-red).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

(✓) R279: 1000 Ω, 1/2-watt (brown-black-red).

(✓) R278: 14.3 kΩ, 1% (brown-yellow-orange-red).

(✓) R281: 6800 Ω (blue-gray-red).

(✓) R282: 51 kΩ, 1/2-watt (green-brown-orange).

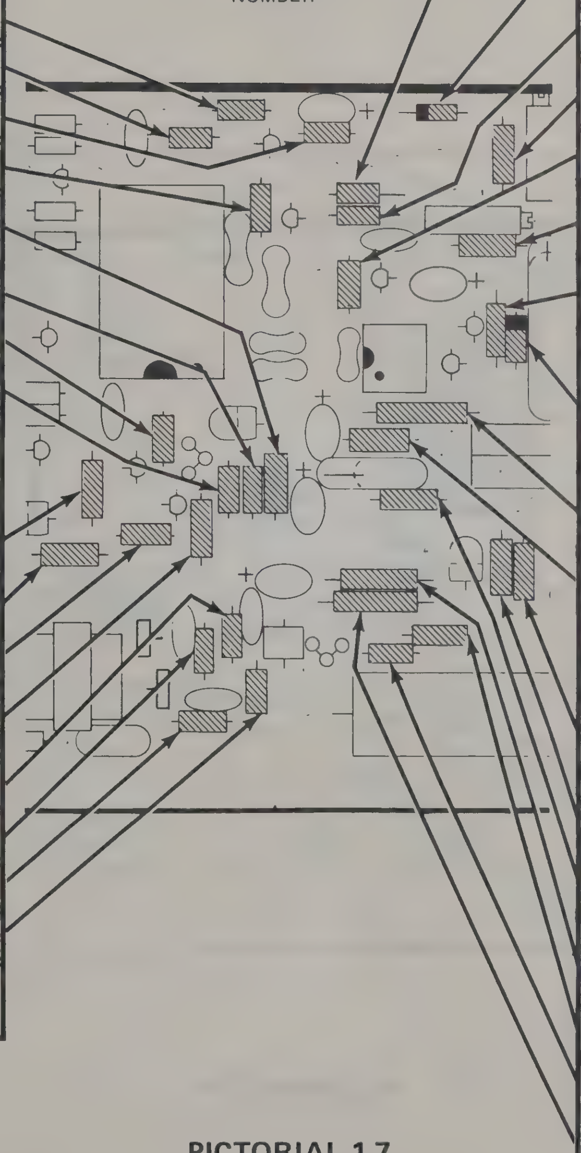
(✓) R297: 560 Ω (green-blue-brown).

(✓) R299: 180 Ω (brown-gray-brown).

(✓) R301: 560 Ω (green-blue-brown).

(✓) R298: 180 Ω (brown-gray-brown).

(✓) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-7

CONTINUE

(✓) R267: 4700 Ω (yellow-violet-red).

IMPORTANT: When you remove the zener diodes from the Calibration Voltage Envelope in the following steps, save both envelopes. You will use the figures recorded on them later to calibrate your Multimeter.

(✓) D218: Remove the diode from the minus (–) calibration voltage envelope and install the diode 1/8" above the circuit board using the alligator clip as a heat sink.

(✓) R268: 6800 Ω (blue-gray-red).

(✓) R258: 49.9 kΩ, 1% (yellow-white-white-red).

(✓) R266: 6800 Ω (blue-gray-red).

(✓) R261: 20 kΩ, 1% (red-black-black-red).

(✓) R263: 2500 Ω, 1% (red-green-black-brown).

(✓) D217: Remove the diode from the plus (+) Calibration Envelope and install the diode 1/8" above the circuit board using the alligator clip as a heat sink.

(✓) R264: 110 kΩ, 1% (brown-brown-black-orange).

(✓) R265: 25 kΩ, 1% (red-green-black-red)

(✓) Solder the leads to the foil and cut off the excess lead lengths.

(✓) R203: 49.9 kΩ, 1% (yellow-white-white-red).

(✓) R204: 51 kΩ, 1/2-watt (green-brown-orange).

(✓) R259: 51.1 Ω, 1% (green-brown-brown-white).

(✓) R201: 5.5 MΩ, 1% (green-green-black-yellow).

(✓) R292: 15 Ω, 1/2-watt (brown-green-black).

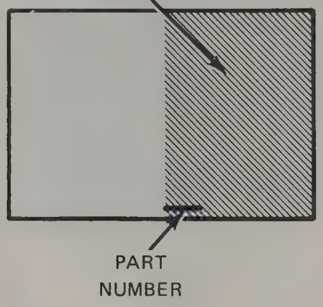
(✓) R291: 1500 Ω (brown-green-red).

(✓) R205: 2730 Ω, 1% (red-violet-orange-brown).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

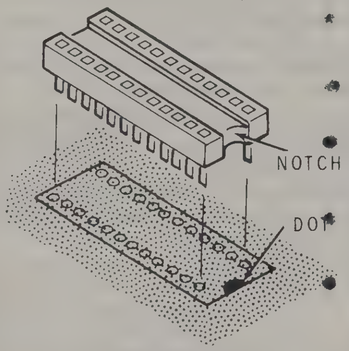
IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.

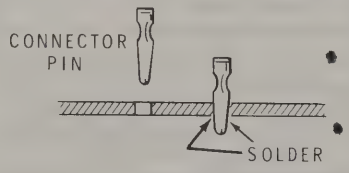


START

( ) 24-pin integrated circuit socket. Match the notch or dot at one end of the socket with the dot on the circuit board. Then insert the socket pins. Make sure all socket pins go through their respective holes; then solder them to the foil.

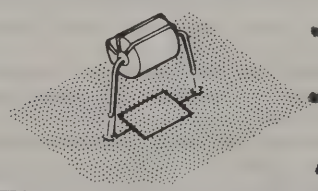


( ) Install six connector pins at Q228A/Q228B. Solder each pin as you install it.



( ) In the same manner, install six connector pins at Q201B/Q201A. Solder each pin as you install it.

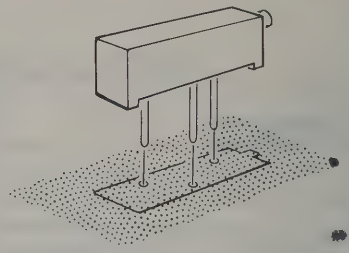
( ) L201: 23 μH coil (#40-1019).



( ) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

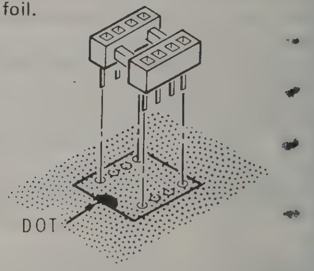
NOTE: When you install controls in the following steps, insert the pins into the holes and push the control down against the circuit board. Then solder the pins to the foil and cut off any excess pin lengths.



( ) R257: 50 kΩ control (#11-149).

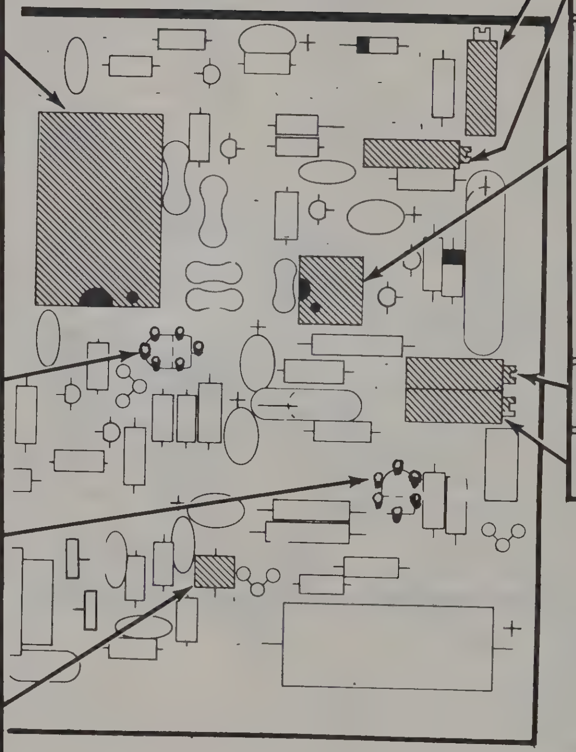
( ) R262: 5000 Ω (5k) control (#11-133).

( ) 8-pin IC socket at IC202. Insert the socket pins and solder them to the foil.



( ) R287: 5000 Ω (5k) control (#11-133).

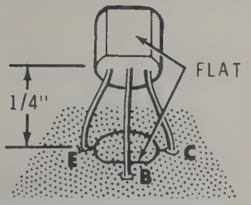
( ) R277: 5000 Ω (5k) control (#11-133).



PICTORIAL 1-8

START

NOTE: Install the following transistors in the manner shown. First line up the flat of the transistor with the flat on the circuit board outline. Insert the transistor leads into their correct holes, which are indicated by E, B, and C. Then bend the leads over slightly on the foil side of the circuit board to hold the transistor in place until you solder the leads.



Install seven MPSA42 transistors (#417-294) at:

(✓) Q216.

(✓) Q215.

(✓) Q213.

(✓) Q217.

(✓) Q211.

(✓) Q214.

(✓) Q212.

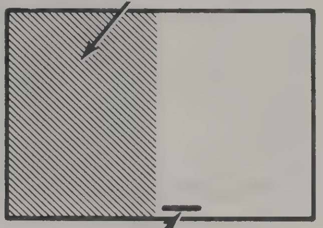
(✓) Q234: MPSA20 transistor (#417-801).

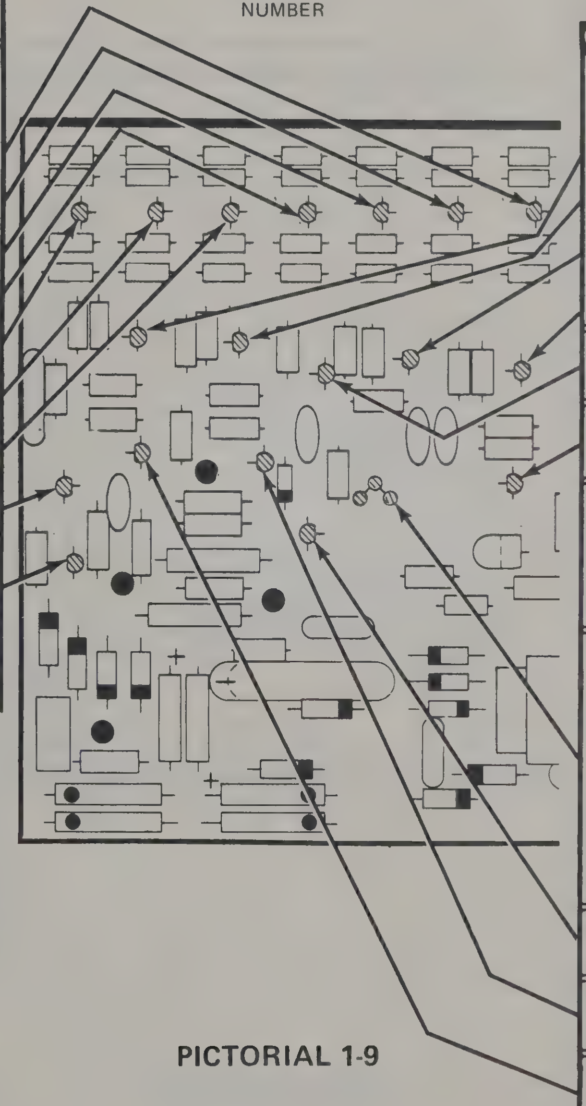
(✓) Q233: MPSA20 transistor (#417-801).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.





PICTORIAL 1-9

CONTINUE

Install four MPSA42 transistors (#417-294) at:

(✓) Q202.

(✓) Q204.

(✓) Q206.

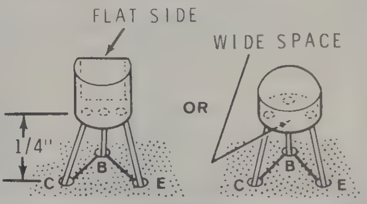
(✓) Q208.

(✓) Q207: MPSL51 transistor (#417-295).

(✓) Q209: MPSL51 transistor (#417-295).

NOTE: The selected zener diodes, like the one used in the following step, are packed in an envelope marked "417-242." Disregard any numbers or markings on these parts.

(✓) D203: Install a selected zener diode (#417-242) as shown.



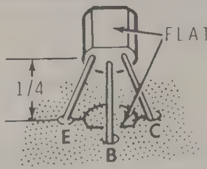
(✓) Q224: MPSA20 transistor (#417-801).

(✓) Q205: MPSL51 transistor (#417-295).

(✓) Q203: MPSL51 transistor (#417-295).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

START



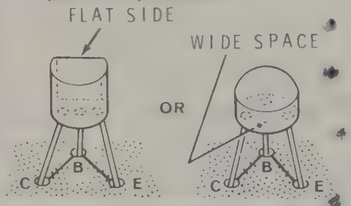
(•) Q223: MPSA20 transistor (#417-801).

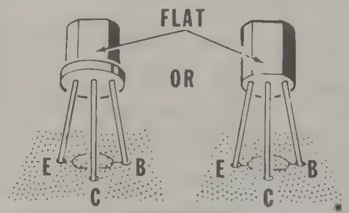
(•) Q222: MPSA20 transistor (#417-801).

(•) Q221: MPSA20 transistor (#417-801).

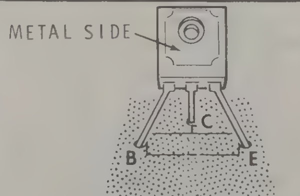
(•) Q226: MPSA20 transistor (#417-801).

(•) D204: Install a selected zener diode (#417-242) as shown.





(•) Q227: X29A829 transistor (#417-201).



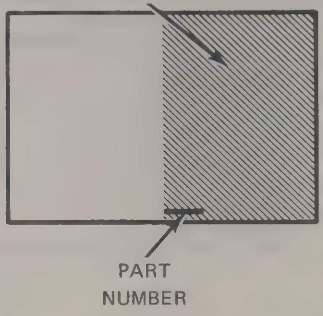
(•) Q231: MJE171 transistor (#417-819).

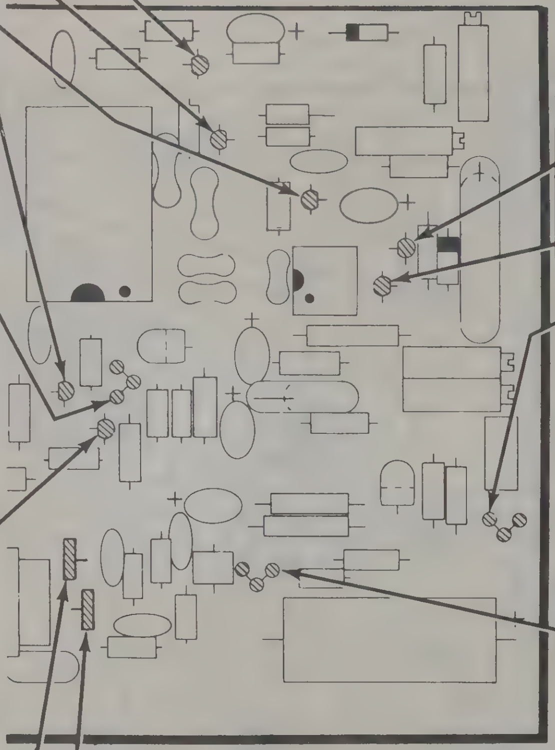
(•) Q232: MJE171 transistor (#417-819).

(•) Solder the leads to the foil and cut off the excess lead lengths.

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.



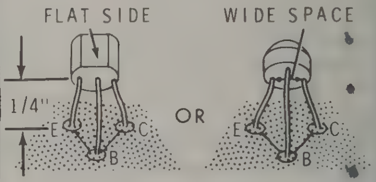


CONTINUE

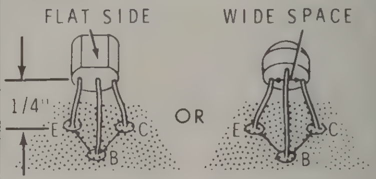
(•) Q219: 2N2712 transistor (#417-67).

(•) Q218: 2N2712 transistor (#417-67).

(•) D201: Install the selected zener diode (#417-242) as shown.



(•) Q229: Install the 2N3638A transistor (#417-234) as shown.

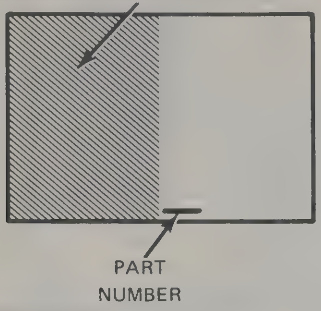


(•) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-10

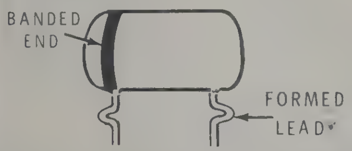
IDENTIFICATION
DRAWING

The steps performed in this Pictorial are in this area of the circuit board.



START

NOTE: When you install Mylar capacitors in the following steps, make sure the formed leads on these capacitors do not touch adjacent foils.



Disregard the banded end on Mylar capacitors.

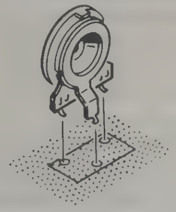
(●) C205: .047 μF Mylar.

(●) C202: .001 μF disc.

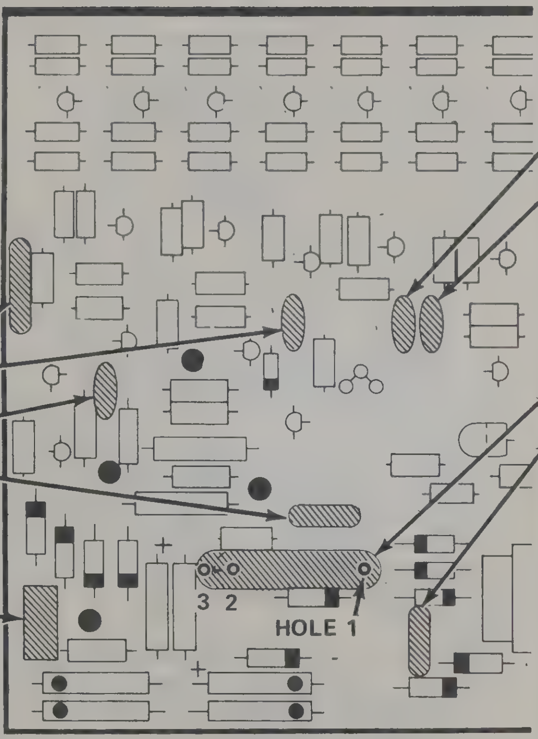
(●) C201: .001 μF disc.

(●) C225: .02 μF disc.

(●) R289: 20 kΩ control (#10-1086).



(●) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

(●) C203: .001 μF disc.

(●) C204: .001 μF disc.

NOTE: The capacitor in the following step may be supplied in either of two sizes. Insert one lead into hole 1 and the other lead into either hole 2 or 3, whichever hole spacing fits best.

(●) C226: 2.2 μF Mylar.

(●) C229: .02 μF disc.

(●) Solder the leads to the foil and cut off the excess lead lengths.

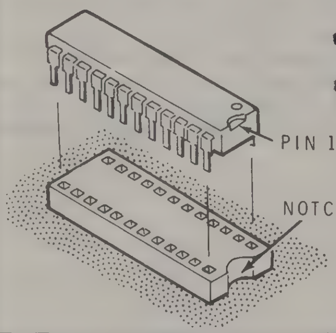
PICTORIAL 1-11

START

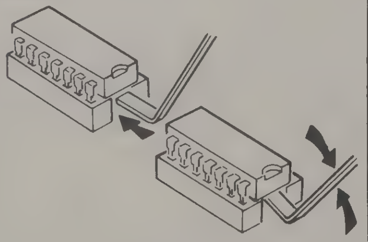
CAUTION: In the following steps, the IC can be damaged by static electricity if it is not handled properly. Make sure you install the IC exactly as instructed.

( ) IC201: Open the package containing the 6013 integrated circuit (#443-626) and install the IC as follows:

1. Remove the IC from its package, with both hands.
2. Remove the foam pad from the IC.
3. Hold the IC in one hand and straighten any bent pins with the other hand.
4. Refer to Detail 1-12A to identify pin 1.
5. Continue holding the IC, being careful not to touch it to anything, while you pick up and hold the circuit board in your other hand.
6. Position pin 1 at the marked end of the socket. Make sure all IC pins are lined up with the socket holes. Then gently push the IC down into the socket.

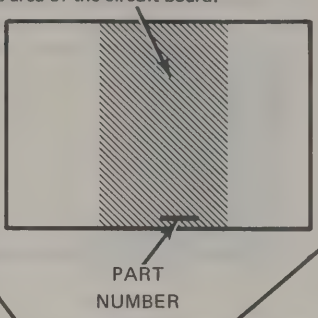


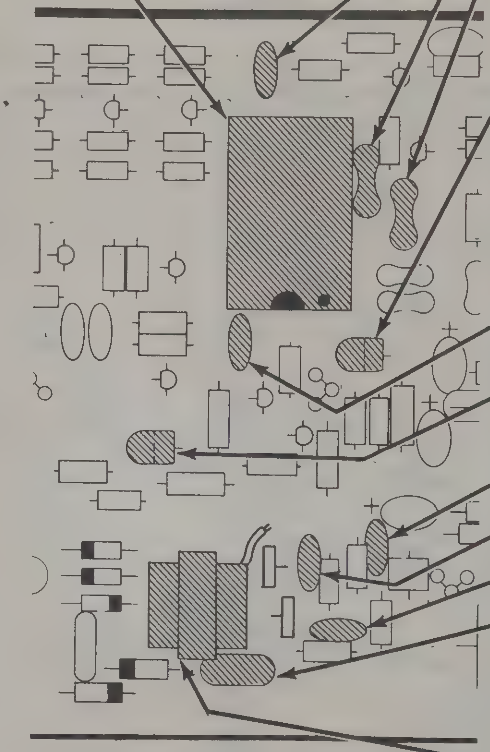
NOTE: An integrated circuit puller has been included with this kit so you do not bend the pins in case you should have to remove an IC from its socket. To use the puller, insert its foot beneath the IC; then gently rock the tool back and forth to lift the IC.



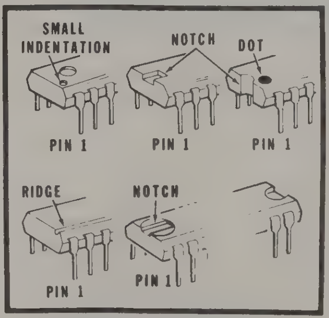
IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.





PICTORIAL 1-12



Detail 1-12A

CONTINUE

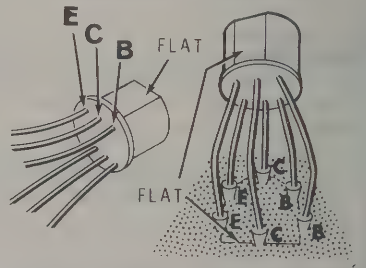
( ) C206: .01 µF disc.

( ) C211: 2200 pF mica.

( ) C209: 1300 pF mica.

NOTE: In the next step, be sure you DO NOT use a TD401 transistor (#417-261).

( ) Q228A/Q228B: TD101 dual transistor (#417-191). Identify the E, C, and B leads; then line up the flat on the transistor with the flat on the circuit board and insert the leads into the correct connector pins.



( ) C219: .01 µF disc.

( ) Q225A/Q225B: TD401 transistor (#417-261). Line up the flat on the transistor with the flat on the circuit board.

( ) C223: .01 µF disc.

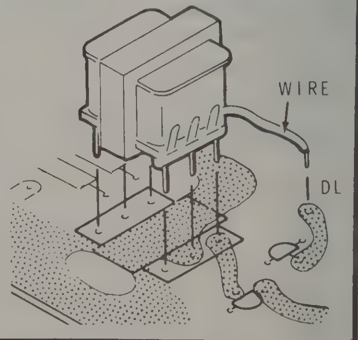
( ) C222: 750 pF disc.

( ) C224: .01 µF disc.

( ) C231: 02 µF disc.

( ) Solder the leads to the foil and cut off the excess lead lengths.

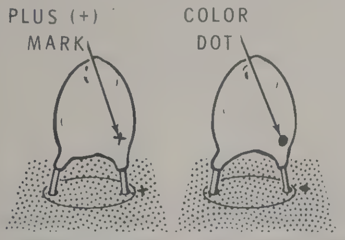
( ) T201: Position the transformer (#54-942) with the wire as shown and insert the pins into the holes. Then, connect the transformer wire to hole DL on the circuit board and solder the pins and wire to the foil.



START

NOTE: When you install tantalum capacitors, always place the marked lead in the plus (+) marked hole on the circuit board.

MAY BE MARKED WITH PLUS SIGN (+) OR COLOR DOT.



(●) C218: 47 μF tantalum.

(●) IC202: LM308AN integrated circuit (#442-66). Refer to Detail 1-13A and identify pin 1. Then position pin 1 at the marked end (notch or arrow head) of the socket and install the IC.

(●) C214: 68 pF mica.

(●) C208: 620 pF mica.

(●) C207: 300 pF mica.

(●) C213: .68 μF tantalum.

(●) C233: 47 μF tantalum.

(●) C221: 47 μF tantalum.

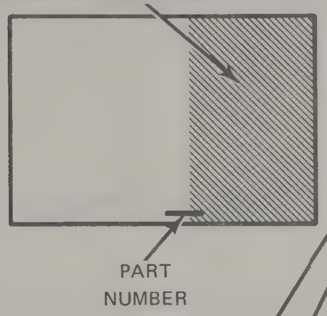
(●) C212: .22 μF Mylar.

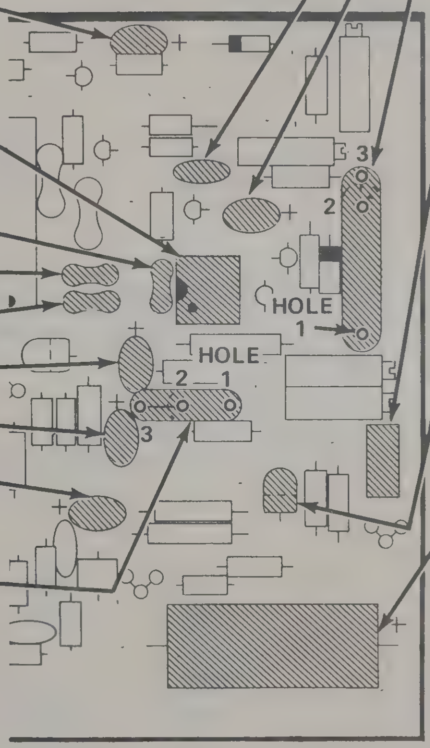
NOTE: This capacitor may be supplied in either of two sizes. Insert one lead into hole 1 and the other lead in hole 2 or 3, whichever hole spacing fits best.

(●) Solder the leads to the foil and cut off the excess lead lengths.

IDENTIFICATION DRAWING

The steps performed in this Pictorial are in this area of the circuit board.





PICTORIAL 1-13

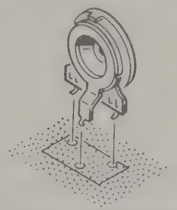
CONTINUE

(●) C216: .01 μF disc.

(●) C232: 47 μF tantalum. Make sure the plus (+) marked lead is in the plus (+) marked hole on the circuit board.

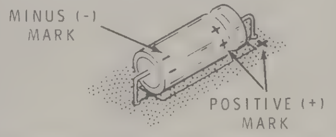
(●) C215: 2.2 μF Mylar. Insert one lead into hole 1 and the other lead into either hole 2 or 3, whichever hole fits best.

(●) R202: 20 kΩ control (#10-1086).



(●) Q201A/Q201B: TD401 dual transistor (#417-261). Line up the flat on the transistor with the flat on the circuit board.

NOTE: When you install electrolytic capacitors, always place the positive (+) lead of the capacitor in the plus (+) marked hole on the circuit board. Be careful; only the negative (−) lead end of the capacitor may be marked.



(●) C217: 2000 μF electrolytic.

(●) Solder the leads to the foil and cut off the excess lead lengths.

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) Poor solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Transistors for the proper type and installation.

( ) Integrated circuits for the correct position of pin 1.

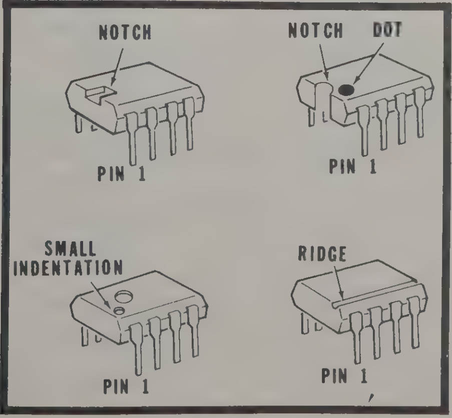
( ) Diodes for the correct position of the banded end.

( ) Electrolytic capacitors for the correct position of the plus (+) marked lead.

NOTE: Save the remaining connector pins. They will be used later.

Set the logic circuit board aside.

FINISH



Detail 1-13A

DISPLAY CIRCUIT BOARD

PARTS LIST

Unpack the parts from Pack #2 and check each part against the following list.

To order a replacement part, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of the Manual. For pricing information, refer to separate "Heath Parts Price List."

RESISTORS

All 5% and 10% resistors have four color bands (last band gold for 5% and silver for 10%). The last band (gold or silver) will not be called out.

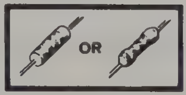
NOTE: Resistors may be packed in more than one envelope. Open all resistor envelopes in this pack before you check the resistors against the Parts List.

1/4-Watt, 5%

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	2400 Ω (red-yellow-red)	1-97-12	R412
( )	1	4700 Ω (yellow-violet-red)	1-76-12	R416
( )	1	6800 Ω (blue-gray-red)	1-78-12	R408
( )	1	10 kΩ (brown-black-orange)	1-80-12	R405
( )	1	18 kΩ (brown-gray-orange)	1-94-12	R414
( )	2	22 kΩ (red-red-orange)	1-91-12	R406,R411

1/4-Watt, 10%

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	4	100 kΩ (brown-black-yellow)	1-32-12	R418,R419, R421,R422
( )	5	470 kΩ (yellow-violet-yellow)	1-18-12	R407,R409, R413,R415, R417
( )	2	1 MΩ (brown-black-green)	1-19-12	R423,R424

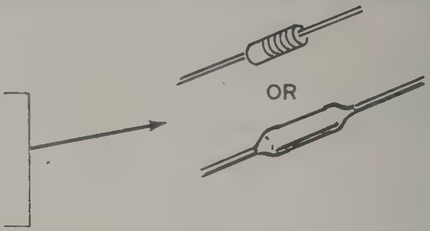


	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.

1/4-Watt, 1%

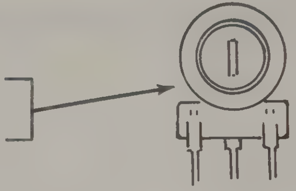
All 1% color coded resistors have five color bands (last band brown). This last band is set apart from the other bands. The last band (brown) will not be called out.

( )	1	6570 Ω, 1% (blue-green-violet-brown)	6-6571-12	R402
( )	1	64 kΩ, 1% (blue-yellow-black-red)	6-6402-12	R404



CONTROLS

( )	1	1000 Ω (1k)	10-936	R401
( )	1	10 kΩ	10-386	R403

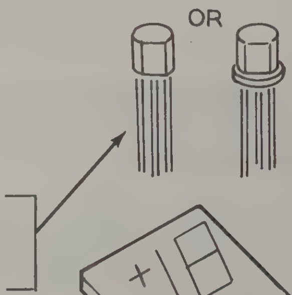


TRANSISTORS

NOTE: Transistors are marked for identification in one of the following four ways:

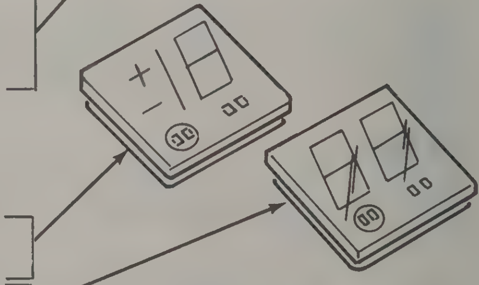
1. Part number.
2. Transistor type number.
3. Part number and type number.
4. Part number with a type other than the one listed.

( )	3	MPSA42	417-294	Q401,Q402, Q404
( )	1	MPSA20	417-801	Q403



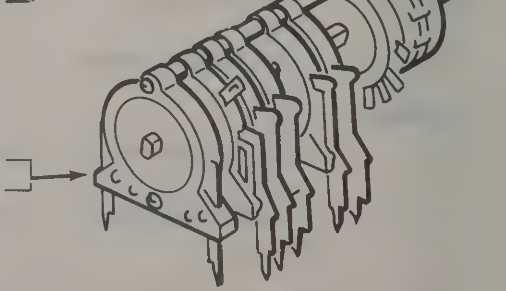
MISCELLANEOUS

( )	1	SP-351 7-segment display tube	411-294	V401
( )	1	SP-352 7-segment display tube	411-295	V402
( )	2	Small solder lug	259-30	



PARTS NEEDED FROM FINAL PACK

( )	1	Display circuit board	85-1375-1	
( )	12″	Small bare wire	340-8	
( )	1	Rotary switch	63-693	SW5

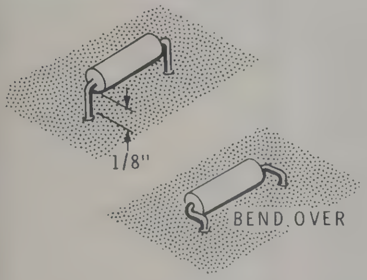


STEP-BY-STEP ASSEMBLY

START

Position the display circuit board as shown. Then perform the following steps.

NOTE: When you install the 1 MΩ resistors in the next two steps, space the resistors about 1/8'' above the circuit board. Solder the leads to the foil and cut off the excess lead lengths. Then bend the resistors over toward the edge of the circuit board as shown.



( ) R423: 1 MΩ, 10% (brown-black-green).

( ) R424: 1 MΩ, 10% (brown-black-green).

( ) R411: 22 kΩ (red-red-orange).

( ) R412: 2400 Ω (red-yellow-red).

( ) R406: 22 kΩ (red-red-orange).

( ) R407: 470 kΩ, 10% (yellow-violet-yellow).

( ) R408: 6800 Ω (blue-gray-red).

( ) R404: 64 kΩ, 1% (blue-yellow-black-red).

( ) R405: 10 kΩ (brown-black-orange).

( ) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

NOTE: When you install the four 100 kΩ resistors in the following steps, space them 1/8'' above the circuit board. Then solder the leads to the foil and cut off the excess lead lengths. As before, bend the resistors over toward the edge of the circuit board.

Install four 100 kΩ, 10% (brown-black-yellow) resistors at the following locations.

( ) R418.

( ) R419.

( ) R421.

( ) R422.

Install three 470 kΩ, 10% (yellow-violet-yellow) resistors at the following locations:

( ) R417.

( ) R413.

( ) R409.

( ) R416: 4700 Ω (yellow-violet-red).

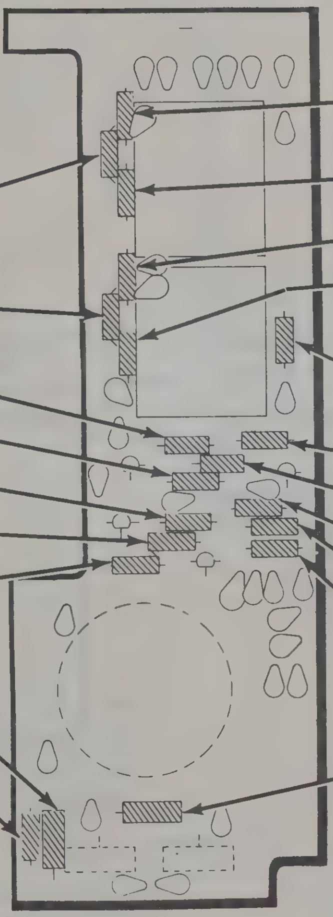
( ) R415: 470 kΩ, 10% (yellow-violet-yellow).

( ) R414: 18 kΩ (brown-gray-orange).

( ) R402: 6570 Ω, 1% (blue-green-violet-brown).

( ) Solder the leads to the foil and cut off the excess lead lengths.

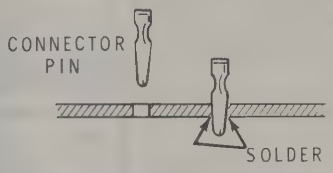
NOTE: Save one of the cutoff resistor leads from a 1/4-watt resistor; it will be used later.



PICTORIAL 2-1

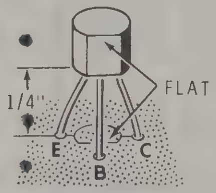
START

(✓) Install and solder twenty connector pins within the outline at V401 as shown.



(✓) In the same manner, install and solder twenty connector pins at V402.

(✓) Q402: MPSA42 transistor (#417-294).

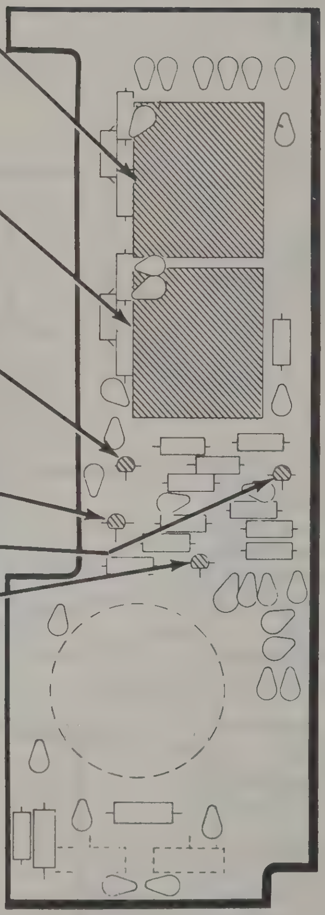


(✓) Q403: MPSA20 transistor (#417-801).

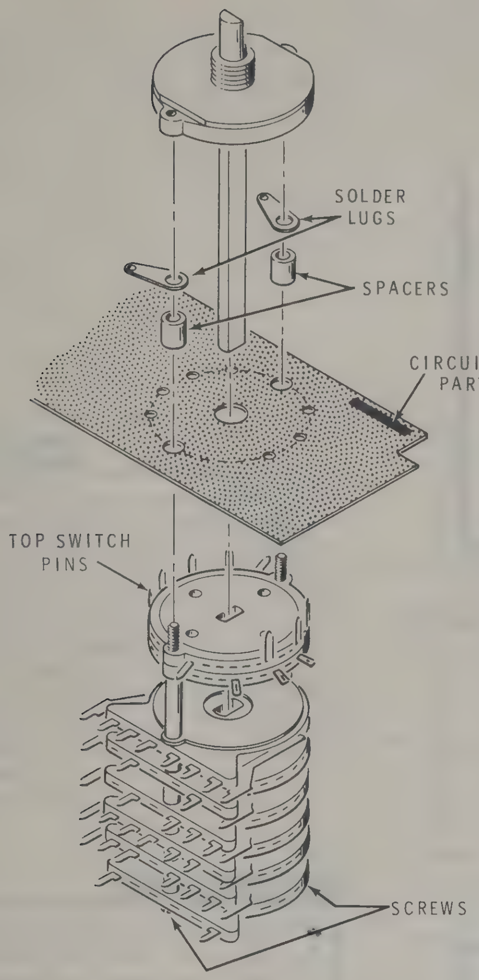
(✓) Q401: MPSA42 transistor (#417-294).

(✓) Q404: MPSA42 transistor (#417-294).

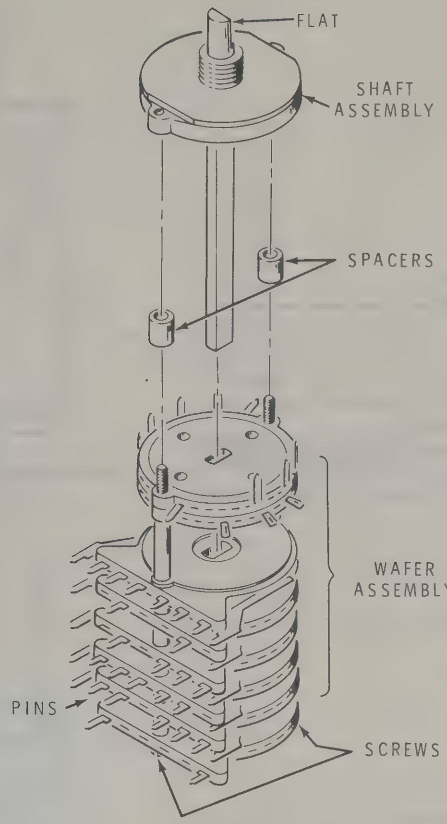
(✓) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 2-2



PICTORIAL 2-3



Detail 2-3A

( ) Locate the rotary switch and position it as shown in Detail 2-3A.

NOTE: In the following numbered steps, you will be instructed to partially disassemble the rotary switch and mount the switch on the display circuit board. Do not disassemble the wafer assembly portion of the switch. First, read all of the numbered steps; then go back and perform each one.

1. ( ) Loosen the two screws just enough to remove the shaft assembly and the two spacers. Do not remove the screws from the wafer assembly.

2. ( ) Position the board as shown in Pictorial 2-3 and insert the top switch pins and the screws through the holes at SW5A.

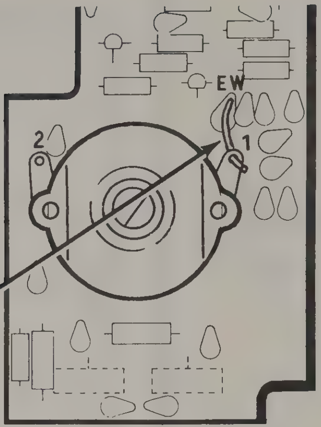
3. ( ) Replace the spacers on the screws. Then place a small solder lug on each screw and position the solder lugs as shown.

4. ( ) Replace the shaft assembly and tighten the screws. You may have to hold the two solder lugs to keep them positioned as shown in the Pictorial while you tighten the screws. The flat on the switch shaft may be positioned either way.

START

(✓) Connect a 1" bare wire from switch solder lug 1 to circuit board hole EW. Solder the wire to the lug and to the circuit board and cut off any excess wire lengths.

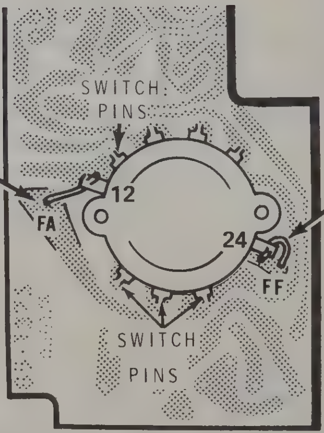
NOTE: Solder lug 2 will not be used.



COMPONENT SIDE OF CIRCUIT BOARD

(✓) Solder the seven switch pins to the foil.

(✓) Connect a 1" bare wire from circuit board hole FA to lug 12. Solder the wire to the lug and to the circuit board foil and cut off any excess wire length.



CONTINUE

(✓) Connect a 1" bare wire from circuit board hole FF to lug 24. Solder the wire to the lug and to the circuit board foil, and cut off any excess wire lengths.

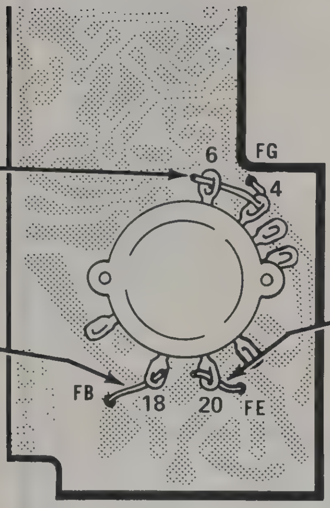
FOIL SIDE OF CIRCUIT BOARD

PICTORIAL 2-4

START

(●) Cut a 1-1/2" bare wire and route the wire up through circuit board hole FG, through lug 4, to lug 6. Solder the wire to both lugs and to the circuit board foil and cut off any excess wire length.

(●) Connect a 1" bare wire from circuit board hole FB to lug 18. Solder the wire to the lug and the circuit board foil and cut off any excess wire length.

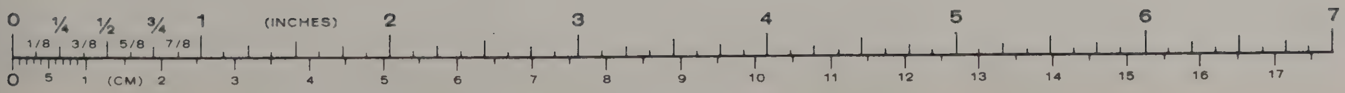


FOIL SIDE OF CIRCUIT BOARD

CONTINUE

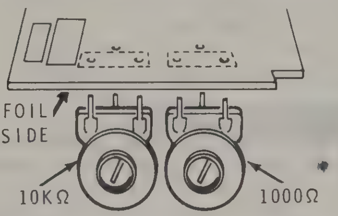
(●) Connect a 1" bare wire from circuit board hole FE to lug 20. Solder the wire to the lug and the circuit board foil and cut off any excess wire length.

PICTORIAL 2-5



START

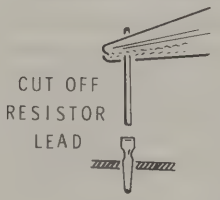
IMPORTANT: In the following steps, install the two controls on the foil side of the circuit board as shown below. Solder each control to the foil as you install it.

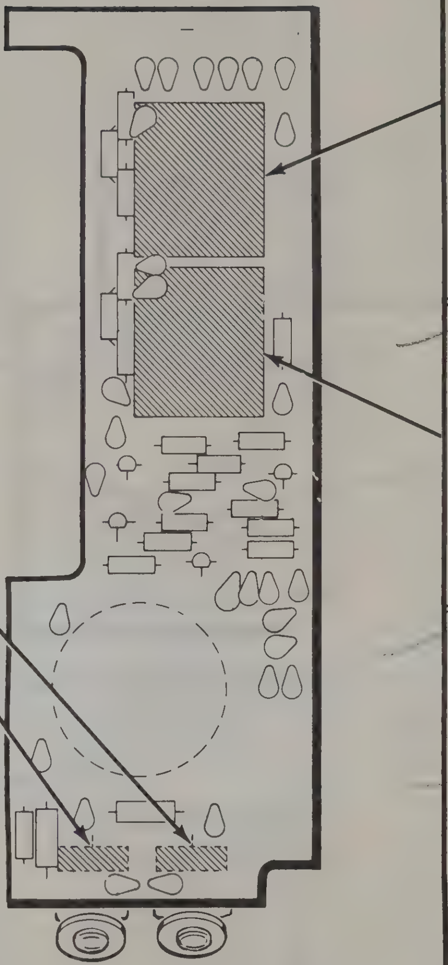


(✓) R401: 1000 Ω (1 k) control (#10-936).

(✓) R403: 10 kΩ control (#10-386).

( ) Locate the cutoff resistor lead you saved earlier. Then, with a pair of pliers, push the resistor lead into each pin to enlarge the opening and make it easier to install the display tubes later. Reheat and straighten any pins that are not straight.



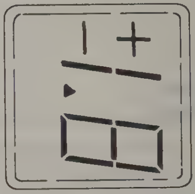


PICTORIAL 2-6

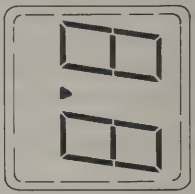
CONTINUE

(✓) Locate the two display tubes and make sure all the pins are straight.

(✓) V401: SP-351 display tube (#411-294). Position the tube as shown. Then make sure all the tube pins line up with the connector pins and push the tube straight down with both hands.



(✓) V402: SP-352 display tube (#411-295). Position the tube as shown.



CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) "Cold" solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Transistors for the proper type and installation.

( ) Switch lugs shorted together by protruding leads or too much solder.

Set the display circuit board aside.

FINISH

INPUT CIRCUIT BOARD

PARTS LIST

Unpack the parts from Pack #3 and check each part against the following list.

To order a replacement part, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of the Manual. For pricing information, refer to the separate "Heath Parts Price List."

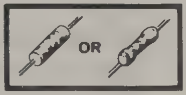
RESISTORS

All 5% and 10% tolerance resisitors have four color bands (last band gold for 5% and silver for 10%). The last band (gold or silver) will not be called out.

NOTE: Resistors may be packed in more than one envelope. Open all resistor envelopes in this pack before you check the resistors against the Parts List.

1/4-Watt, 5%

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	1500 Ω (brown-green-red)	1-71-12	R112
( )	1	3300 Ω (orange-orange-red)	1-74-12	R111
( )	1	5600 Ω (green-blue-red)	1-77-12	R106
( )	3	22 kΩ (red-red-orange)	1-91-12	R102, R139, R141
( )	1	33 kΩ (orange-orange-orange)	1-82-12	R103



1/4-Watt, 10%

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	2	100 kΩ (brown-black-yellow)	1-32-12	R107, R108
( )	1	10 MΩ (brown-black-blue)	1-88-12	R131

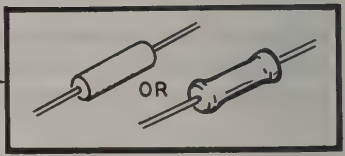
1/4-Watt, 1%

All 1% color coded resistors have five color bands (last band brown). This last band is set apart from the other bands. The last band (brown) will not be called out.

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	301 Ω (orange-black-brown-black)	6-3010-12	R116
( )	2	3010 Ω (orange-black-brown-brown)	6-3011-12	R114, R115
( )	1	10 kΩ (brown-black-black-red)	6-1002-12	R113
( )	3	30.1 kΩ (orange-black-brown-red)	6-3012-12	R118, R119, R121
( )	1	75 kΩ (violet-green-black-red)	6-7502-12	R122

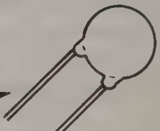
714

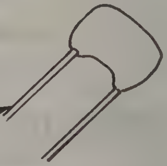
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
1/2-Watt, 5%				
( )	1	15 Ω (brown-green-black)	1-54	R109
( )	1	390 Ω (orange-white-brown)	1-94	R124
( )	3	100 kΩ, low-noise (brown-black-yellow)	4-34	R123,R132, R133
1/2-Watt, 10%				
( )	1	47 kΩ (yellow-violet-orange)	1-25	R101
Precision				
( )	1	.096 Ω, .1%	3-14-3	R138
( )	1	.9 Ω, .1%	3-7-3	R137
( )	1	9 Ω, .1%	3-6-3	R136
( )	1	90 Ω, .1%	3-5-3	R135
( )	1	900 Ω, .1%	2-27-12	R134
( )	1	9955 Ω, .1%	2-726-12	R105
( )	1	90 kΩ, .1%	2-618-12	R104
( )	1	90.9 kΩ,.5% (1/2%)	2-294	R129



CAPACITORS

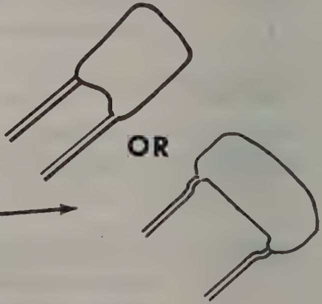
	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
Disc				
( )	1	6.8 pF	21-61	
( )	2	3.3 pF	21-33	C105, C106
( )	2	4.7 pF	21-168	C115, C116
( )	1	7.7 pF	21-181	C104
( )	1	4700 pF (.0047)	21-144	C114
( )	1	.02 µF, 1600V (1.6 KV)	21-122	C113
Mica				
( )	1	150 pF	20-103	C102
( )	1	390 pF	20-106	C118

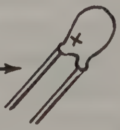


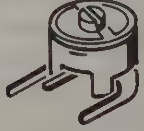


NOTE: Mylar and tantalum capacitors can be marked three different ways. EXAMPLE: .1, .1k, or .1 µF. However, the Parts List and installation instructions will always use µF.

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
Mylar				
( )	1	.005 µF	27-133	C121
( )	1	.22 µF	27-85	C122
Tantalum				
( )	2	2.2 µF	25-221	C111,C112
( )	3	15 µF	25-252	C101,C103, C107
( )	2	33 µF	25-253	C108,C109
Ceramic Trimmer Capacitors				
( )	1	7-25 pF	31-67	C117
( )	1	15-60 pF	31-63	C119



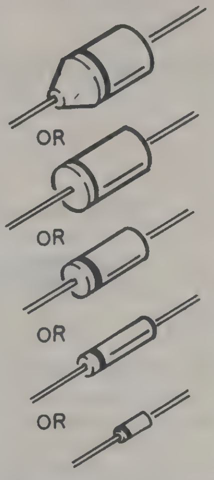




DIODES

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	2	GD510	56-89	D103,D104
( )	3	FD333	56-93	D101,D102, D106
( )	1	1N2071	57-27	D105
( )	2	3A1	57-42	D109,D111
( )	1	1N4002	57-65	D112
( )	2	Silicon rectifier	57-71	D107,D108

NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.

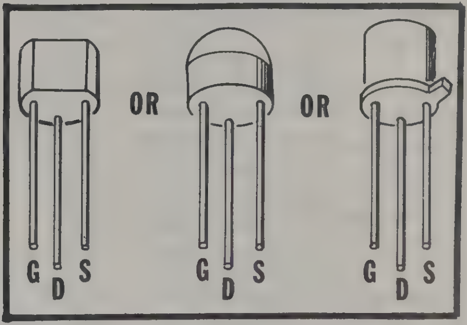


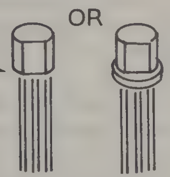
TRANSISTORS-INTEGRATED CIRCUIT

NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways:

1. Part number.
2. Type number.
3. Part number and type number.
4. Part number with a type number other than the one listed.

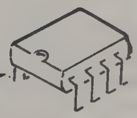
( )	1	2N4304 transistor	417-140	Q101
( )	1	X29A829 transistor	417-201	Q102





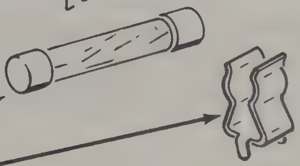
NOTE: If either the part number or the "Description" number is on an integrated circuit, you have the correct part. Disregard any other numbers. On integrated circuits, the description number may have additional letters or numbers other than those given in the list. EXAMPLE: SN(7490)N or MC(7490)P.

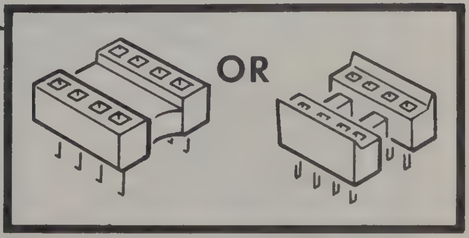
( )	1	301 integrated circuit	442-39	IC101

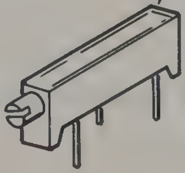


MISCELLANEOUS

( )	1	3-ampere 3AG fuse	421-2	F101
( )	1	1/32-ampere 3AG fuse	421-38	F102
( )	4	Fuse clip	260-65	
( )	1	8-pin IC socket	434-230	
( )	1	500 Ω control	10-362	R117





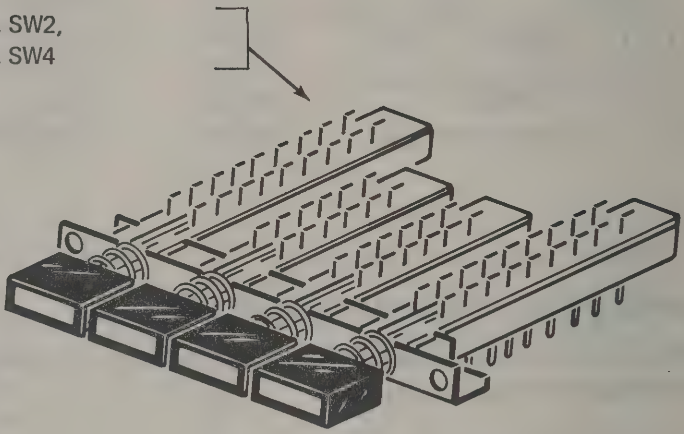


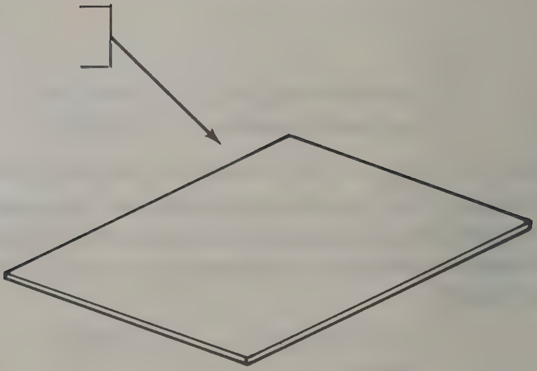
NOTE: Make sure you place the following four resistors back in the envelope after you identify them.

( )	1	Envelope of matched resistors containing:	9-60	
	1	*10 kΩ, precision*		*R128*
	1	*90 kΩ, precision*		*R127*
	2	*4.95 MΩ, precision*		*R125,R126*

PARTS NEEDED FROM FINAL PACK

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	Pushbutton switch	64-671	SW1, SW2, SW3, SW4
( )	1	15″ white wire	344-59	
( )	1	48″ large red wire (do not use the 36″ larger more flexible red test lead wire)	344-3	
( )	1	30″ large black wire (do not use the 36″ larger more flexible black test lead wire)	344-2	
( )	1	72″ shielded cable	343-15	
( )	1	5″ × 8″ cardboard insulator	75-179	
( )	1	Input circuit board	85-1911-2	





STEP-BY-STEP ASSEMBLY

START

( ) Locate the 6.8 pF disc capacitor and tape this capacitor in the top margin on Page 83. This capacitor is supplied for calibration purposes only. Then return to this Page.

( ) Position the input circuit board as shown.

Install two 100 kΩ, low-noise, 1/2-watt (brown-black-yellow) resistors at:

(●) R132. . . . .

(●) R123. . . . .

(●) R131: 10 MΩ, 10% (brown-black-blue).

(●) R107: 100 kΩ, 10% (brown-black-yellow).

(●) R133: 100 kΩ, low-noise (brown-black-yellow).

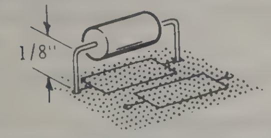
(●) D105: 1N2071 diode (#57-27). See Detail 3-1A.

(●) R124: 390 Ω, 1/2-watt (orange-white-brown).

(●) D106: FD333 diode (#56-93). 1N53[illegible]

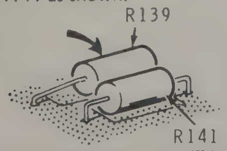
(●) Solder the leads to the foil and cut off the excess lead lengths.

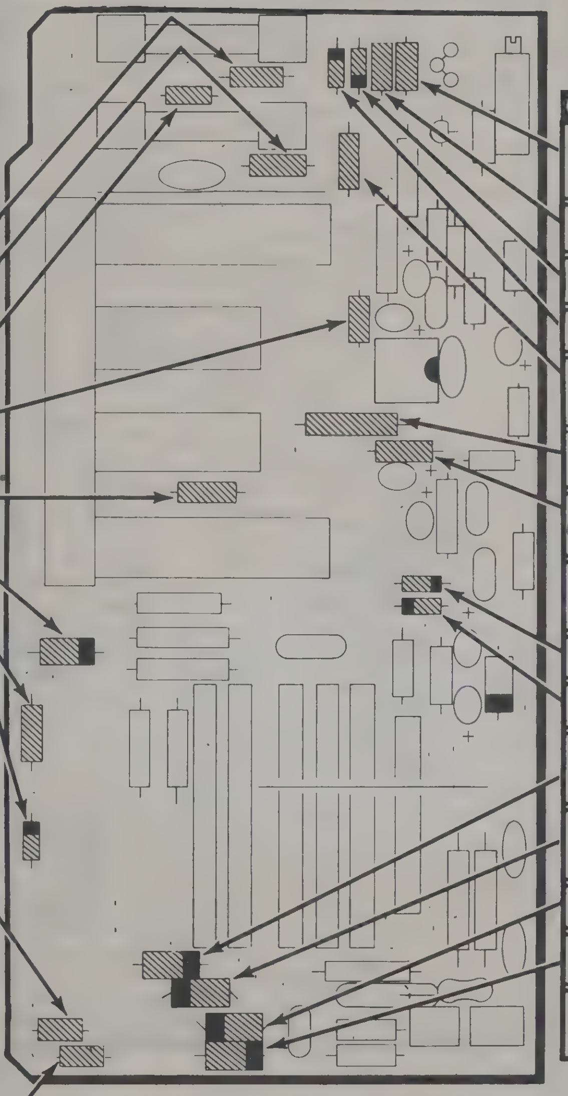
(●) R139: 22 kΩ (red-red-orange). Position this resistor 1/8" above the circuit board. Then solder the leads to the foil and cut off the excess lead lengths.



(●) R141: 22 kΩ (red-red-orange). Solder the leads to the foil and cut off the excess lead lengths.

(●) Bend resistor R139 over resistor R141 as shown.





CONTINUE

(●) R103: 33 kΩ (orange-orange-orange).

(●) R102: 22 kΩ (red-red-orange).

(●) D102: FD333 diode (#56-93).

(●) D101: FD333 diode (#56-93).

(●) R101: 47 kΩ, 1/2-watt (yellow-violet-orange).

(●) R122: 75 kΩ, 1% (violet-green-black-red).

( ) R109: 15 Ω, 1/2-watt (brown-green-black).

( ) Solder the leads to the foil and cut off the excess lead lengths.

(●) D104: GD510 diode (#56-89).

(●) D103: GD510 diode (#56-89).

(●) D107: Selected silicon rectifier (#57-71).

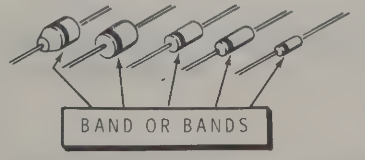
(●) D108: Selected silicon rectifier (#57-71).

(●) D109: 3A1 diode (#57-42).

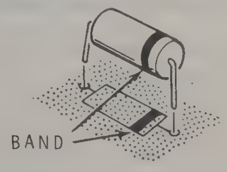
(●) D111: 3A1 diode (#57-42).

(●) Solder the leads to the foil and cut off the excess lead lengths.

Note: Diodes may be supplied in any of the following shapes.



When you install diodes, always position the banded end as shown on the circuit board.



Detail 3-1A

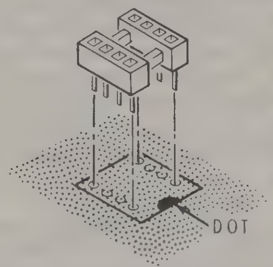
START

(✓) R116: 301 Ω, 1% (orange-black-brown-black).

NOTE: In the next two steps, install the precision resistors 1/8" above the circuit board using the alligator clip as a heat sink.

(✓) R104: 90 kΩ, .1% (1/10%) precision.

(✓) R105: 9955 Ω, .1% (1/10%) precision.



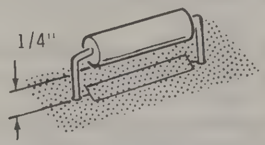
(✓) 8-pin IC socket at IC101. Solder the pins to the foil.

(✓) R114: 3010 Ω, 1% (orange-black-brown-brown).

(✓) R134: 900 Ω, .1% precision.

(✓) R135: 90 Ω, .1% precision.

(✓) R136: 9 Ω, .1% precision.

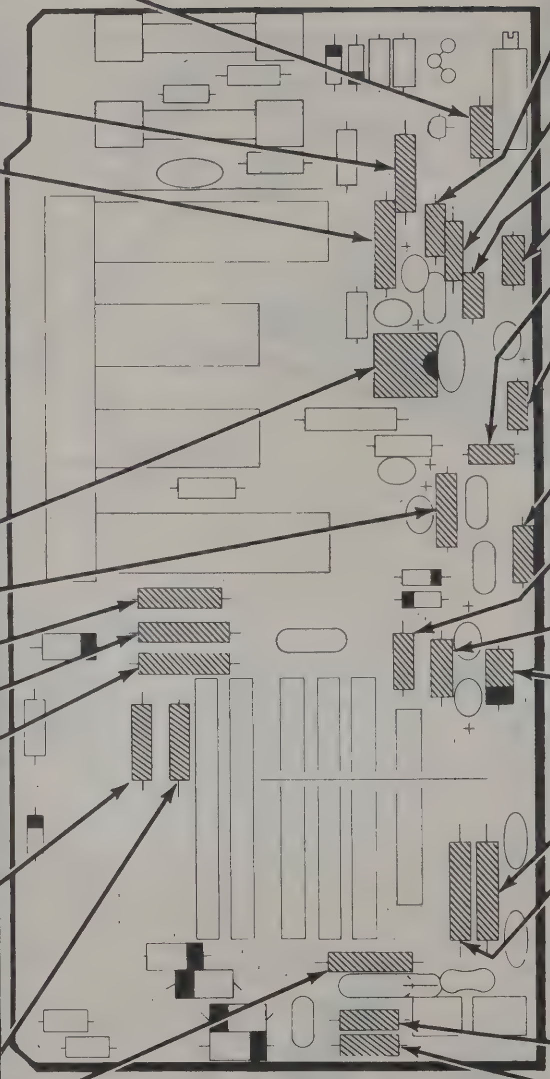


(✓) R138: .096 Ω, .1% precision. Install this resistor 1/4" above the circuit board.

(✓) R137: .9 Ω, .1% precision.

(✓) R129: 90.9 kΩ, .5% (1/2%) precision.

(✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

(✓) R113: 10 kΩ, 1% (brown-black-black-red).

(✓) R115: 3010 Ω, 1% (orange-black-brown-brown).

(✓) R111: 3300 Ω (orange-orange-red).

(✓) R112: 1500 Ω (brown-green-red).

(✓) R108: 100 kΩ, 10% (brown-black-yellow).

(✓) R106: 5600 Ω (green-blue-red).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

(✓) R118: 30.1 kΩ, 1% (orange-black-brown-red).

(✓) R121: 30.1 kΩ, 1% (orange-black-brown-red).

(✓) R119: 30.1 kΩ, 1% (orange-black-brown-red).

(✓) D112: 1N4002 diode (#57-65).

Remove the matched set of resistors from the package marked "9-60" and install the resistors at the following locations:

(✓) R125: 4.95 MΩ, precision.

(✓) R126: 4.95 MΩ, precision.

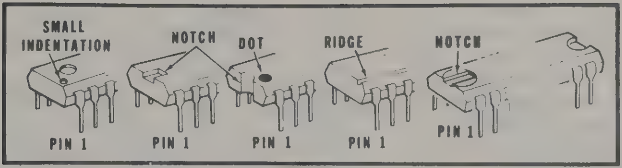
NOTE: In the next two steps, install the precision resistors 1/8" above the circuit board using the alligator clip as a heat sink.

(✓) R127: 90 kΩ, precision.

(✓) R128: 10 kΩ, precision.

( ) Solder the leads to the foil and cut off the excess lead lengths.

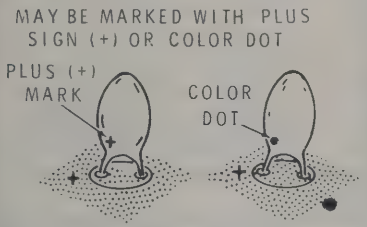
PICTORIAL 3-2



Detail 3-3A

START

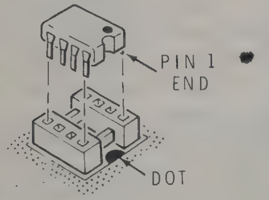
NOTE: When you install tantalum capacitors, always place the marked lead in the plus (+) marked hole on the circuit board.



(✓) C101: 15 μF tantalum.

(✓) C109: 33 μF tantalum.

NOTE: When you install the 8-pin IC in the following step, make sure the pin 1 end is positioned toward the dot on the circuit board.



(✓) IC101: 301 integrated circuit (#442-39). Refer to Detail 3-3A to identify pin 1.

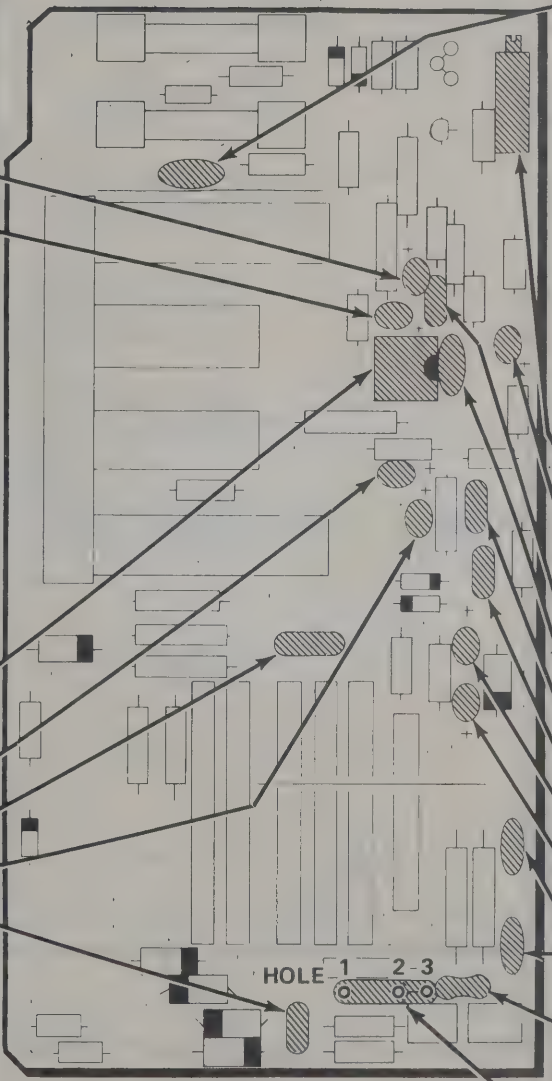
(✓) C108: 33 μF tantalum.

(✓) C114: 4700 pF (.0047) disc.

(✓) C107: 15 μF tantalum.

(✓) C121: .005 μF Mylar.

(✓) Solder the leads to the foil and cut off the excess lead lengths.

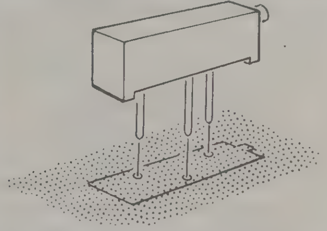


PICTORIAL 3-3

CONTINUE

(✓) C113: .02 μF, 1600V (1.6 KV) disc.

NOTE: When you install the control in the following steps, insert the pins into the holes and push the control down against the circuit board. Then solder the pins to the foil and cut off any excess pin lengths.



(✓) R117: 500 Ω control (#10-362).

(✓) C103: 15 μF tantalum. Make sure you match the marked lead with the plus (+) mark on the circuit board.

(✓) C102: 150 pF mica.

(✓) C104: 7.7 pF disc.

(✓) C105: 3.3 pF disc.

(✓) C106: 3.3 pF disc.

(✓) C111: 2.2 μF tantalum.

(✓) C112: 2.2 μF tantalum.

(✓) C115: 4.7 pF disc.

(✓) C116: 4.7 pF disc.

(✓) C118: 390 pF mica. NOTE: The circuit board is marked "445" at this location.

(✓) C122: .22 μF Mylar. Insert one lead into hole 1 and the other lead into either hole 2 or hole 3, whichever hole spacing fits best.

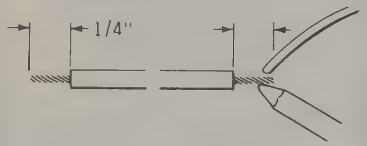
(✓) Solder the leads to the foil and cut off the excess lead lengths.

START

( ) Locate the two 36" test leads (black and red) and lay them aside so you do not accidentally use them to wire the kit in the following steps. The test leads are larger and more flexible than the other wires.

NOTES:

1. To prepare the lengths of wire in the following steps, cut the wire to the length specified in the step; then remove 1/4" of insulation from each end. Where stranded wire is used, twist the strands together and melt a small amount of solder on each end to hold the strands together.



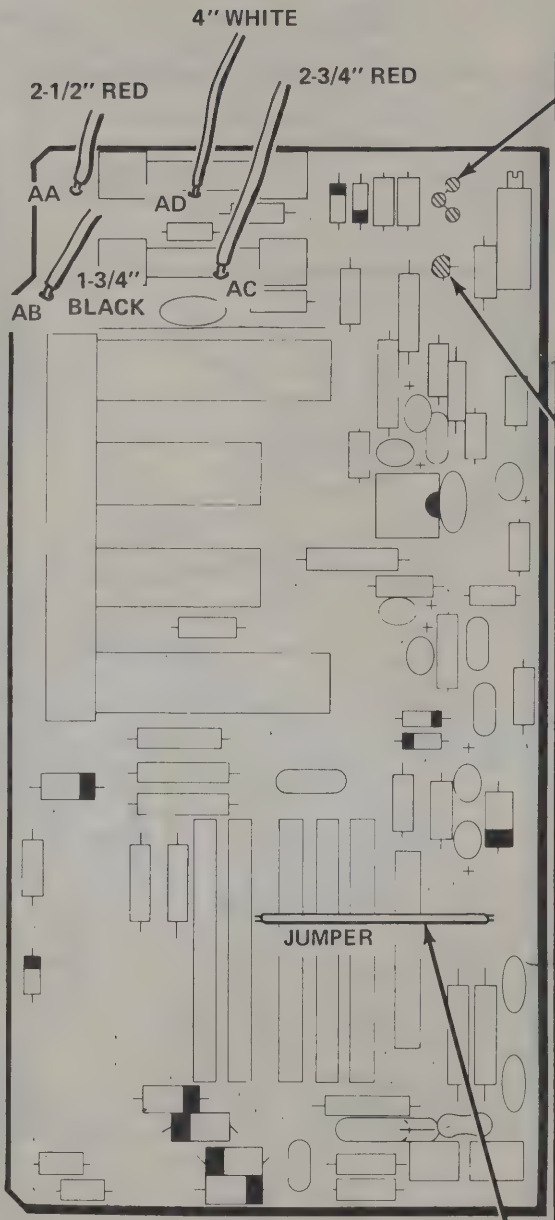
2. You will connect only one end of each wire in the following steps. The other end will be connected later. When you connect the wires, insert the end through the indicated holes on the component side of the circuit board and solder the wire on the foil side of the circuit board. Cut off any excess wire lengths on the foil side of the circuit board.

(●) 2-1/2" large red stranded at hole AA.

(●) 1-3/4" large black stranded at hole AB. Do not use the shielded cable.

(●) 4" white solid at hole AD.

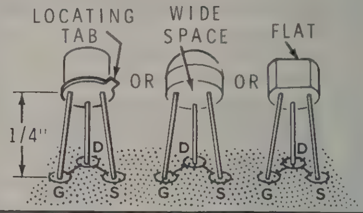
(●) 2-3/4" large red stranded at hole AC.



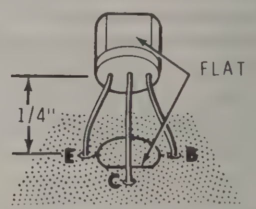
PICTORIAL 3-4

CONTINUE

(●) Q101: 2N4304 transistor (#417-140). Position the locating tab as shown.



(●) Q102: X29A829 transistor (#417-201). Line up the flat on the transistor with the flat on the circuit board.

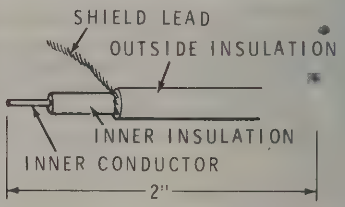


(●) Solder the transistor leads to the foil and cut off the excess lead lengths.

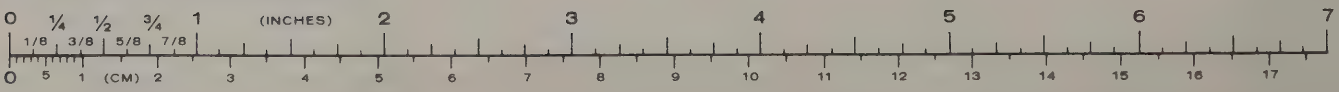
NOTE: In the following step, shielded cable will be used to make a high-voltage jumper wire. Do not use any other wire to make this jumper.

(●) Prepare a 2" length of shielded cable as follows:

1. Remove and discard all of the outside insulation and the shield lead.
2. Remove 1/4" of inner insulation from each end.

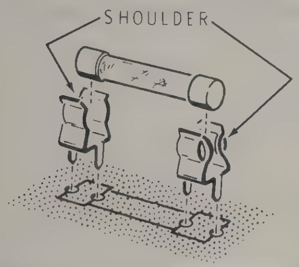


(●) Install the prepared wire at J. Solder the wire to the foil and cut off any excess wire lengths.



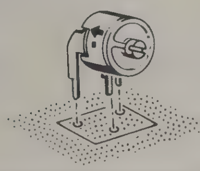
START

( ) F101: Install two fuse clips and a 3-ampere, 3 AG fuse (#421-2). Make sure you position the shoulder of each clip as shown. Solder the clip lugs to the foil after you install the fuse.



( ) F102: In the same manner, install two fuse clips and a 1/32-ampere, 3 AG fuse (#421-38). Solder the clip lugs to the foil.

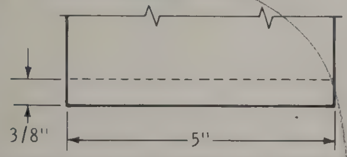
( ) C117: 7-25 pF ceramic trimmer (#31-67). Solder the three lugs to the foil.



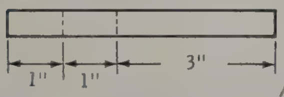
( ) C119: 15-60 pF ceramic trimmer (#31-63). NOTE: Solder only the center lug to the foil.

( ) Locate the push-button switch and the 5" x 8" cardboard insulator.

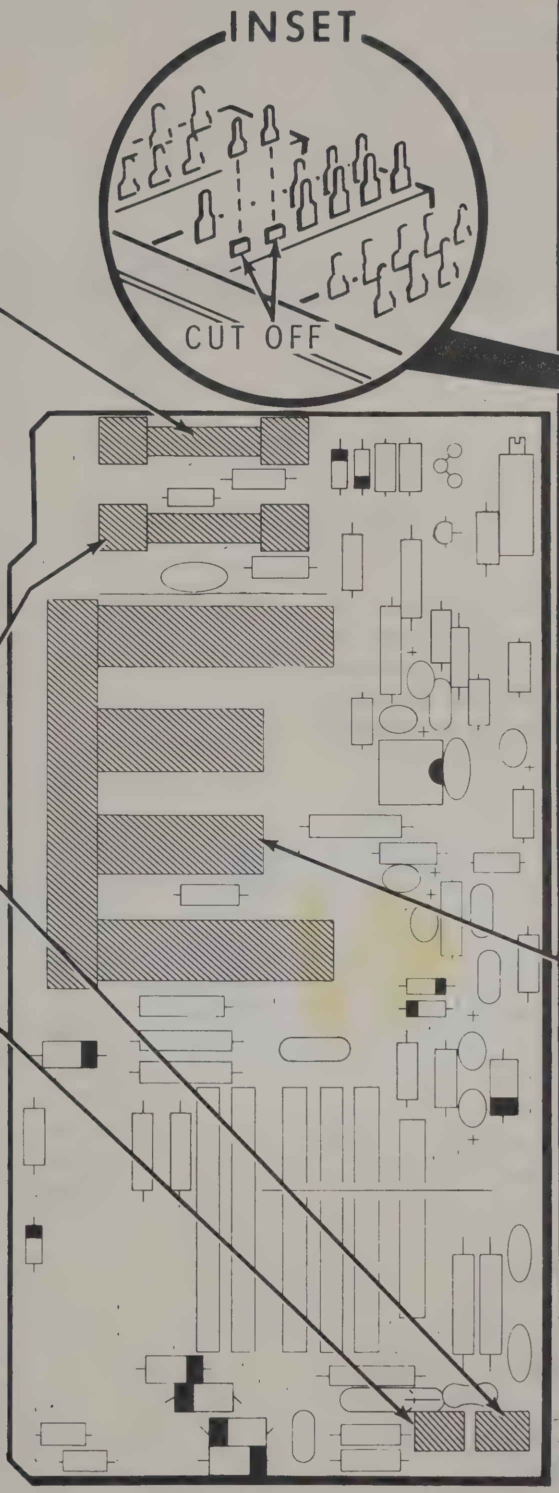
( ) Cut a 3/8" wide strip from one end of the insulator as shown.



( ) Cut two 1" lengths from the 3/8" wide strip and set them aside. They will be used later.



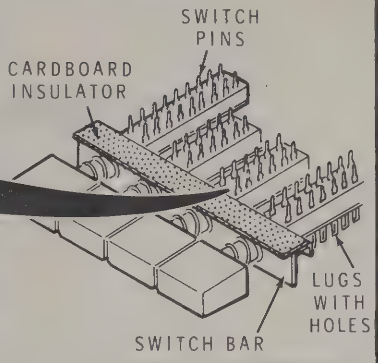
?



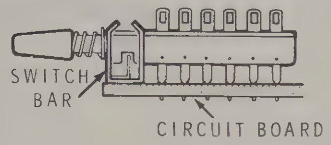
PICTORIAL 3-5

CONTINUE

( ) Position the pushbutton switch as shown below and cut off the two switch pins as shown on the inset drawing. Then remove the backing paper from the remaining 3" length of insulator and press it into place on the switch bar.

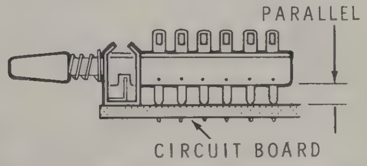


( ) Install the switch assembly on the circuit board by carefully inserting all the switch pins into their mounting holes. Then push the assembly onto the circuit board.



Make sure the switch bar is against the circuit board along its entire length.

Also make sure the assembly is parallel with the circuit board. Then turn the assembly over and solder two pins on each end of the switch assembly. Check the switch assembly and make sure it is straight. Then solder the other switch pins to the foil.



CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) "Cold" solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Diodes for the correct position of the banded end.

( ) Transistors for the proper type and installation.

( ) Integrated circuit for the correct position of pin 1.

( ) Electrolytic capacitors for the correct position of the plus (+) marked lead.

FINISH

GENERAL ASSEMBLY AND WIRING

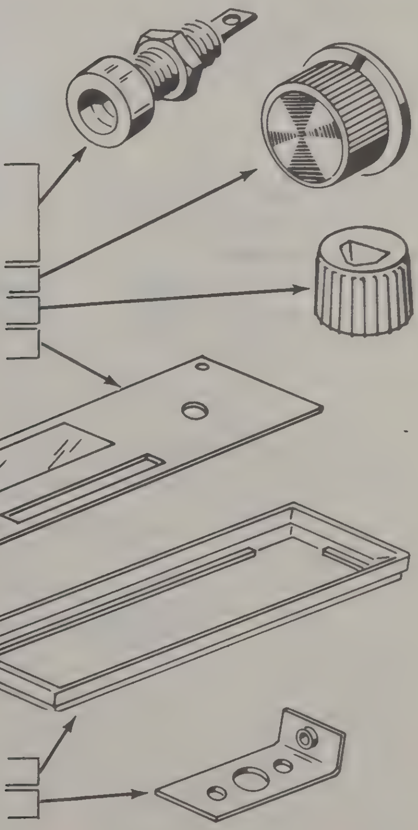
PARTS LIST

Unpack all the remaining parts and check each part against the following list.

To order a replacement part, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of the Manual. For pricing information, refer to the separate "Heath Parts Price List."

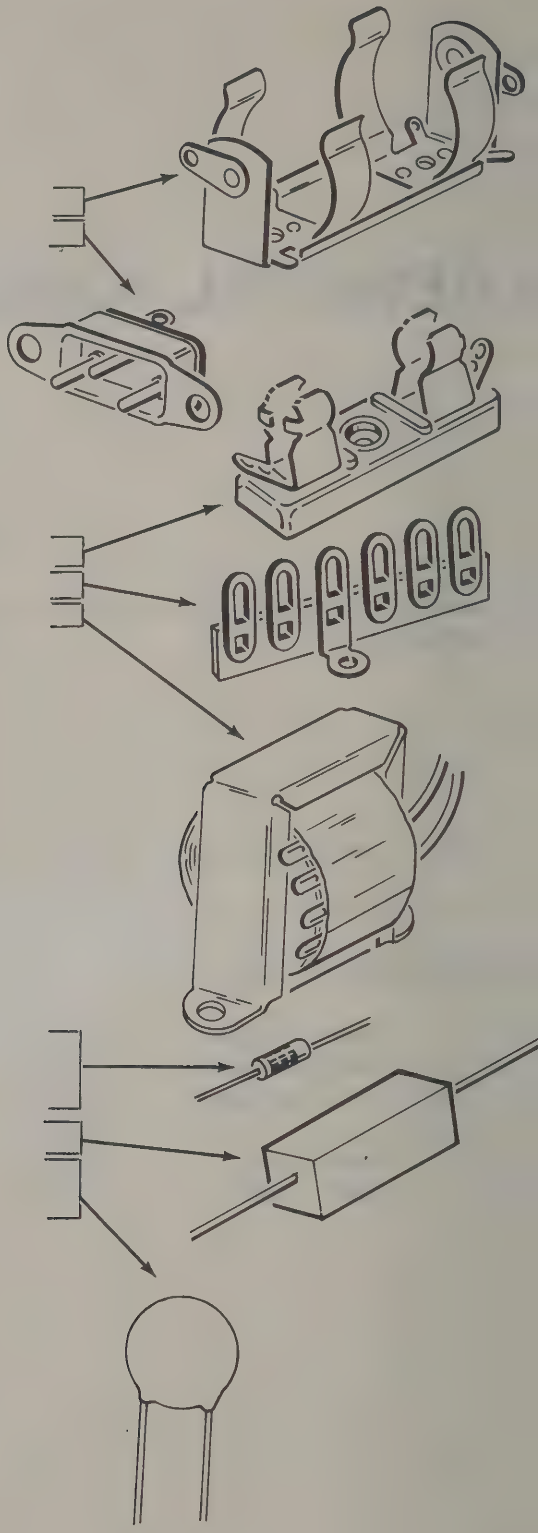
FRONT PANEL PARTS

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	1	Input jack (red)	436-11	
( )	1	Input jack (white)	436-24	
( )	1	Input jack (black)	436-22	
( )	1	Knob	462-264	
( )	1	Knob insert	455-50	
( )	1	Display window	446-618	
( )	1	Front panel	210-89	
( )	2	Mounting bracket	204-1933	

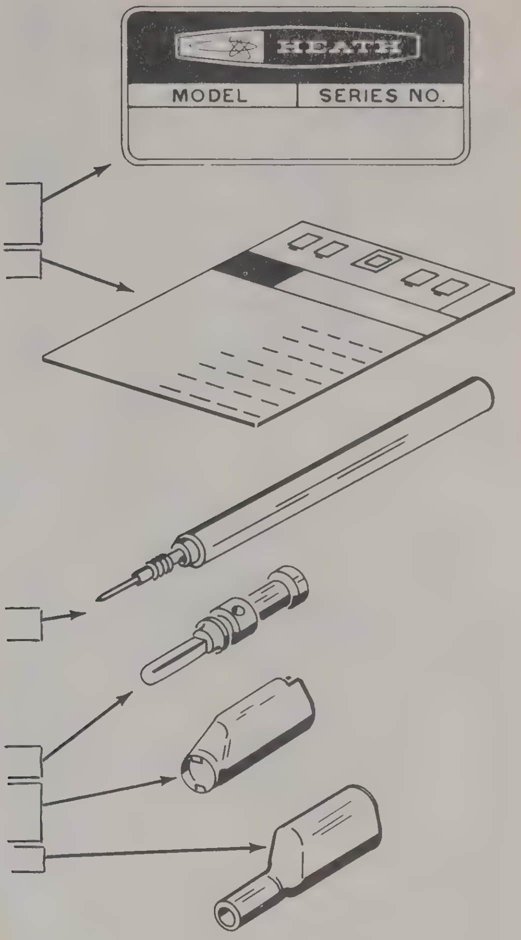


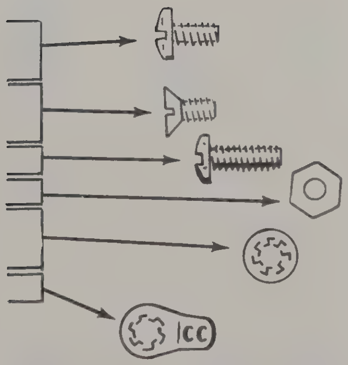
CHASSIS MOUNTED PARTS

	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
( )	4	Battery clip	214-66	
( )	1	AC socket	432-76	
( )	1	Fuseholder	422-1	
( )	1	Terminal strip	431-55	
( )	1	Power transformer	54-842	T1
( )	1	15 MΩ, 1/4-watt, 5% resistor (brown-green-blue-gold)	1-144-12	R130
( )	1	8 Ω, 7-watt resistor	3-24-7	R1
( )	1	Capacitor .02 μF (1.6 KV)	21-122	C1

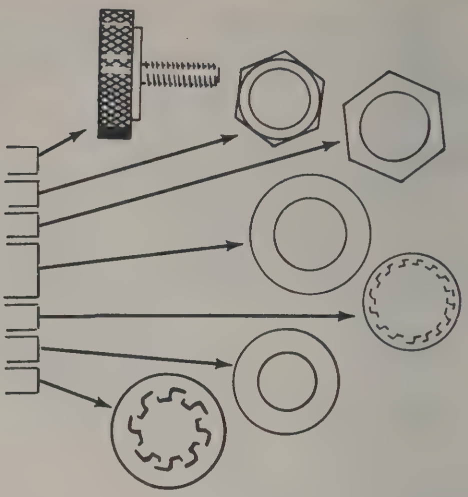


	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
LABELS				
( )	1	Blue and white identification label	391-34	
( )	1	Combination label card	390-1083	
TEST LEAD PARTS				
( )	1	36″ red test lead	341-2	
( )	1	36″ black test lead	341-1	
( )	1	Test probe	439-7	
( )	2	Input plug	438-47	
( )	1	Black plug insulator	70-10	
( )	1	Red plug insulator	70-11	
( )	1	Alligator clip insulator	73-21	
HARDWARE				
#6 Hardware				
( )	2	6-32 x 1/4″ screw	250-56	
( )	8	6-32 x 1/4″ black screw	250-452	
( )	4	6-32 x 1/4″ black flat head screw	250-1109	
( )	13	6-32 x 3/8″ black screw	250-381	
( )	15	6-32 nut	252-3	
( )	7	#6 lockwasher	254-1	
( )	8	#6 black lockwasher	254-33	
( )	1	#6 solder lug	259-1	

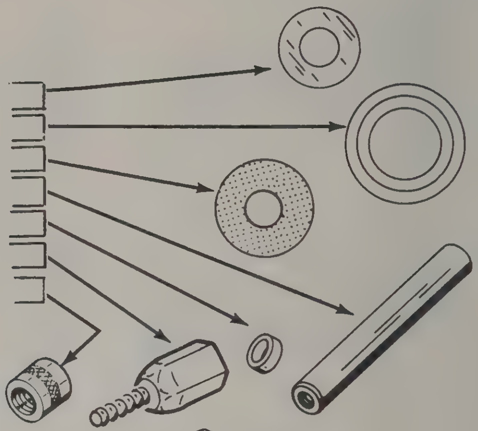




	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
Other Hardware				
( )	2	Thumb screw	250-527	
( )	3	5/16" nut	252-101	
( )	1	3/8" control nut	252-7	
( )	1	3/8" control flat washer	253-119	
( )	1	3/8" lockwasher	254-5	
( )	3	5/16" flat washer	253-86	
( )	3	5/16" lockwasher	254-15	



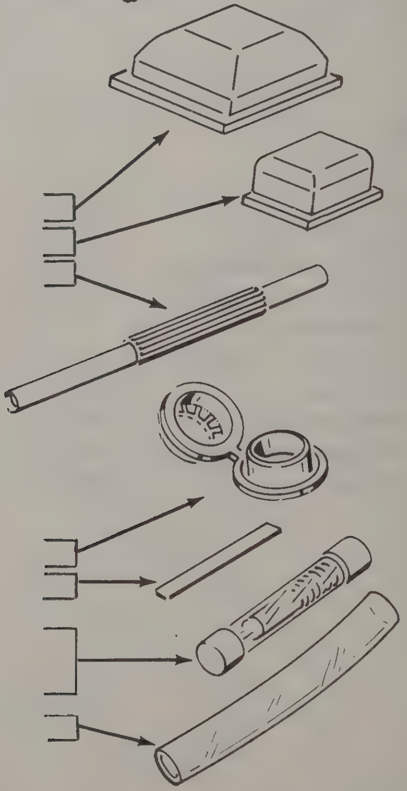
( )	2	#10 brass flat washer	253-8	
( )	1	Fiber shoulder washer	253-16	
( )	2	Felt washer	253-85	
( )	2	2" spacer	255-63	
( )	2	1/16" spacer	255-74	
( )	2	Spacer stud	266-876	
( )	1	Probe collar	439-9	



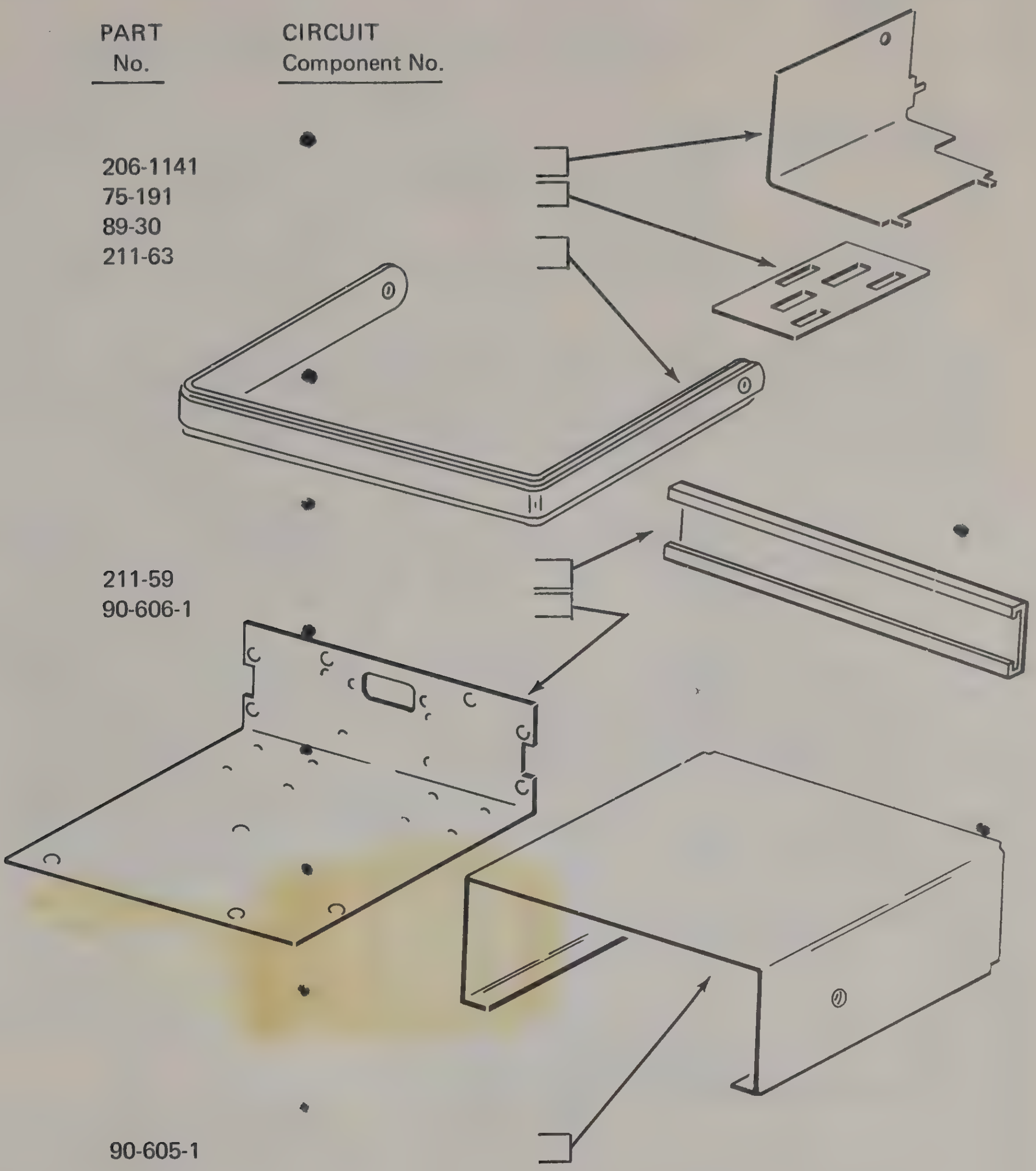
MISCELLANEOUS

( )	1	Wire harness	134-871	
( )	4	Large foot	261-34	
( )	2	Small foot	261-29	
( )	1	Plastic nut starter	490-5	

( )	1	Plastic grommet	73-45	
( )	1	Alignment blade	205-778	
( )	6"	Green wire	344-32	
( )	1	1/8-ampere fuse (3AG)	421-26	
( )	1	1/16-ampere fuse (3AG)	421-27	
( )	1	Insulator tubing	346-26	



	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
		Miscellaneous (cont'd.)		
)	1	Shield	206-1141	
)	1	Fiber insulator	75-191	
)	1	Line cord	89-30	
)	1	Handle	211-63	
)	1	Handle grip	211-59	
)	1	Chassis	90-606-1	
( )	1	Cabinet	90-605-1	
( )	4	Battery (nickel-cadmium 2A/HR, C-cell)	418-29	



STEP-BY-STEP ASSEMBLY

CIRCUIT BOARD WIRING

Refer to Pictorial 4-1 for the following steps.

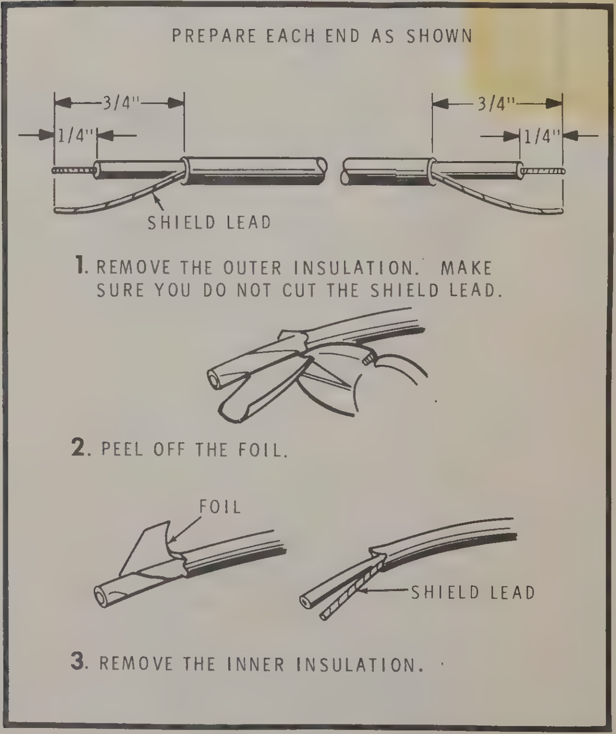
( ) Position the input circuit board as shown in the Pictorial.

NOTE: In the following steps, (NS) means not to solder because other wires will be added later. "S–" with a number, such as (S-3), means to solder the connection. The number following the "S" tells how many wires are at the connection.

(●) Locate the 4" white wire coming from hole AD on the circuit board and connect the free end to switch SW3, lug 5 (S-1). Position the wire as shown in the Pictorial.

NOTE: To prepare the lengths of wire in the following steps, cut the wire to the specified length. Then remove 1/4" of insulation from each end. Position all wires as shown in the Pictorial and push them down against the circuit board.

(●) Connect a 1-1/2" white wire between SW3 lug 11 (S-1) and SW4 lug 15 (S-1).


PREPARE EACH END AS SHOWN
3/4"
1/4"
3/4"
1/4"
SHIELD LEAD
1. REMOVE THE OUTER INSULATION. MAKE SURE YOU DO NOT CUT THE SHIELD LEAD.
2. PEEL OFF THE FOIL.
FOIL
SHIELD LEAD
3. REMOVE THE INNER INSULATION.

Detail 4-1A

(●) Connect a 4-1/2" white wire between SW4 lug 7 (S-1) and circuit board hole AX (S-1).

NOTE: When shielded cable is called for in the following steps, cut the cable to the length specified in the step; then refer to Detail 4-1A and prepare the cable as shown in the Detail.

(●) At one end of a 3" shielded cable, connect the inner conductor to SW1 lug 5 (S-1) and the shield lead to SW1 lug 13 (NS).

(●) At the other end, connect the inner conductor to SW3 lug 10 (S-1). Then cut off the shield lead at this end, close to the insulation.

(●) At one end of a 4" shielded cable, connect the inner conductor to hole AE (S-1) and the shield wire to hole AF (S-1).

(●) At the other end, connect the inner conductor to SW4 lug 10 (NS) and the shield lead to circuit board hole AJ (NS).

(●) At one end of a 3-1/2" shielded cable, connect the inner conductor to SW4 lug 10 (S-2) and the shield lead to circuit board hole AJ (S-2).

(●) At the other end, connect the inner conductor to hole AR (S-1) and the shield lead to circuit board hole AS (S-1).

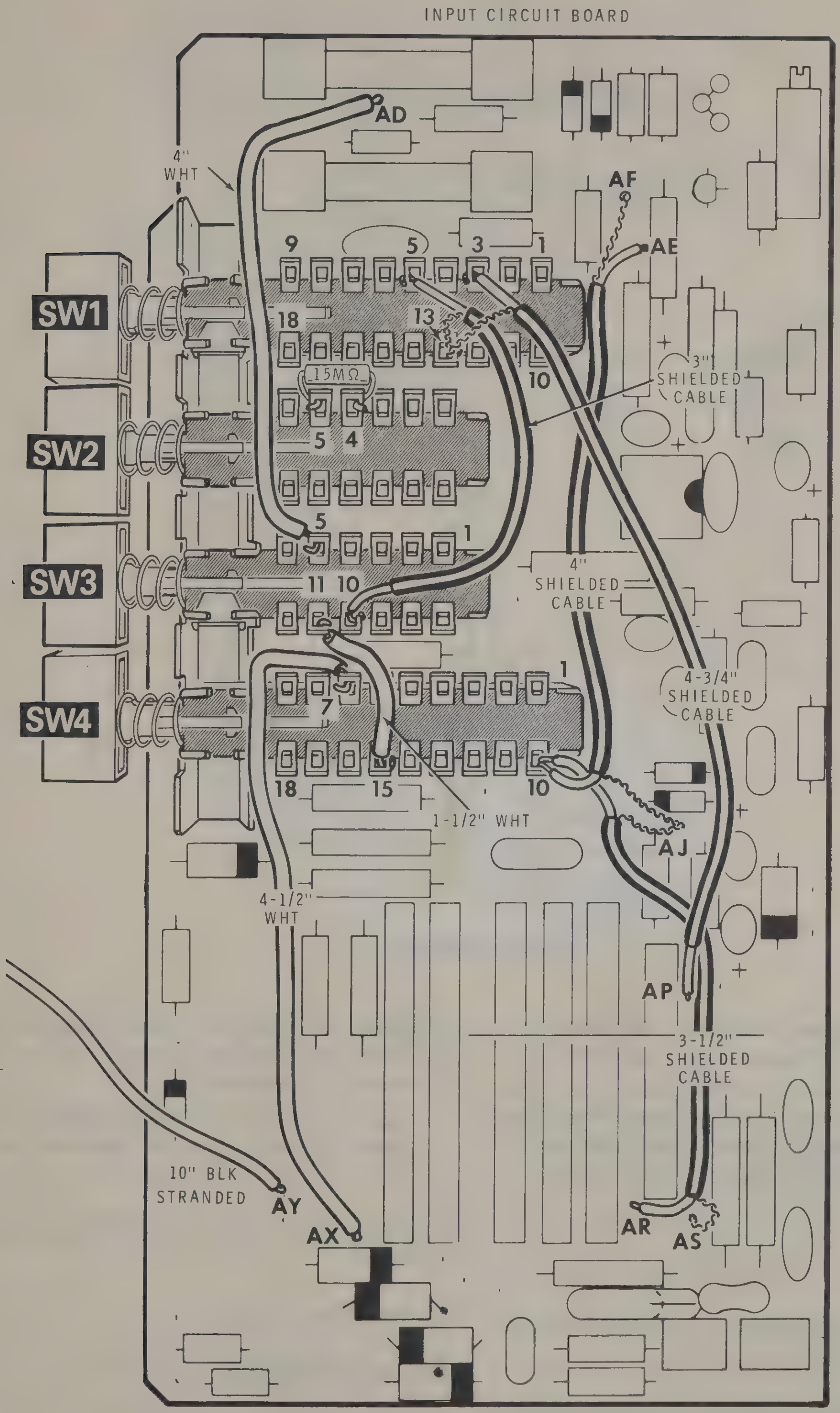
(●) At one end of a 4-3/4" shielded cable, connect the inner conductor to SW1 lug 3 (S-1) and the shield lead to SW1 lug 13 (S-2).

(●) At the other end, connect the inner conductor to circuit board hole AP (S-1). Cut off the shield lead close to the insulation.

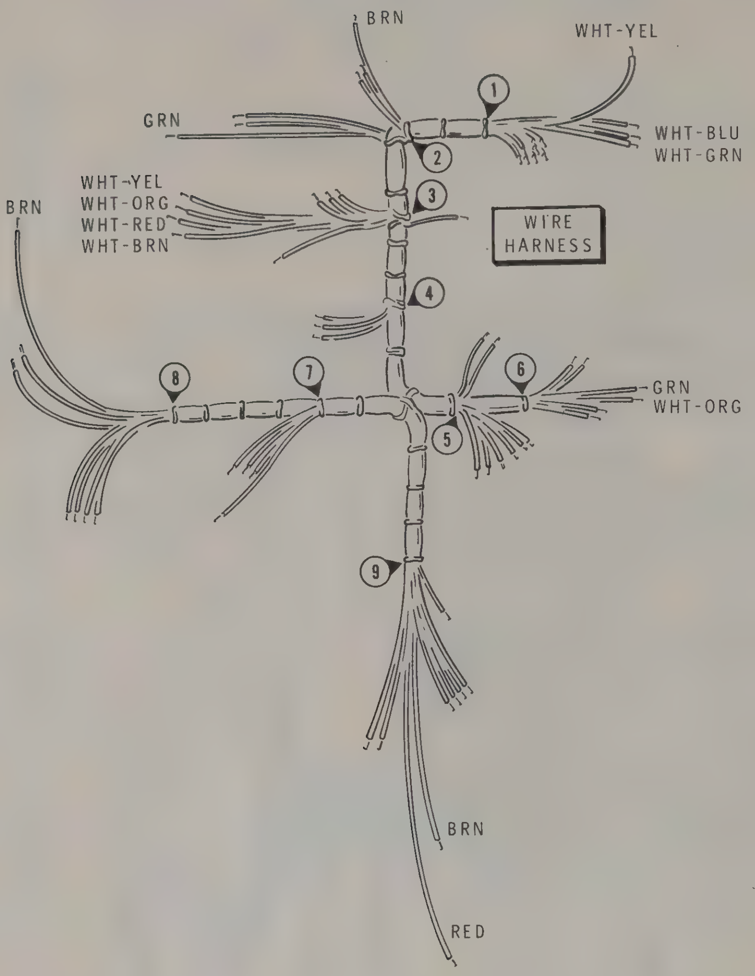
(●) Cut a 10" black stranded wire and connect one end of this wire to hole AY on the circuit board (S-1). The other end of this wire will be connected later.

(●) R130: Connect a 15 MΩ, 5% (brown-green-blue-gold) resistor between SW2 lug 4 (NS) and SW2 lug 5 (S-1). Cut off the excess lead lengths.

( ) Carefully inspect the circuit board to make sure the bare wire ends touch only the lugs to which they are soldered. Cut off any excess wire ends. Then set the circuit board aside.



PICTORIAL 4-1



PICTORIAL 4-2

( ) Locate the wire harness (#134-871) and shape the harness as shown in Pictorial 4-2. The term "BO" (breakout) refers to a place where a group of wires come out of the harness. Each breakout is identified by a number. During the following steps, refer back to this Pictorial whenever necessary to identify the breakouts.

Refer to Pictorial 4-3 for the following steps.

( ) Position the display circuit board and the wire harness as shown in the Pictorial.

NOTE: In the following steps, you will be instructed to connect the harness wires to the foil side of the circuit board. To do this, insert the bare wire ends about 1/8" into the circuit board holes and solder them to the foil. Make sure you do not cover any adjacent holes with solder. Also be careful not to burn the insulation on the wires. Solder each wire as you connect it.

( ) Connect the orange wire from BO#3 of the wire harness to hole EN. NOTE: Make sure you do not use the orange wire from BO#4.

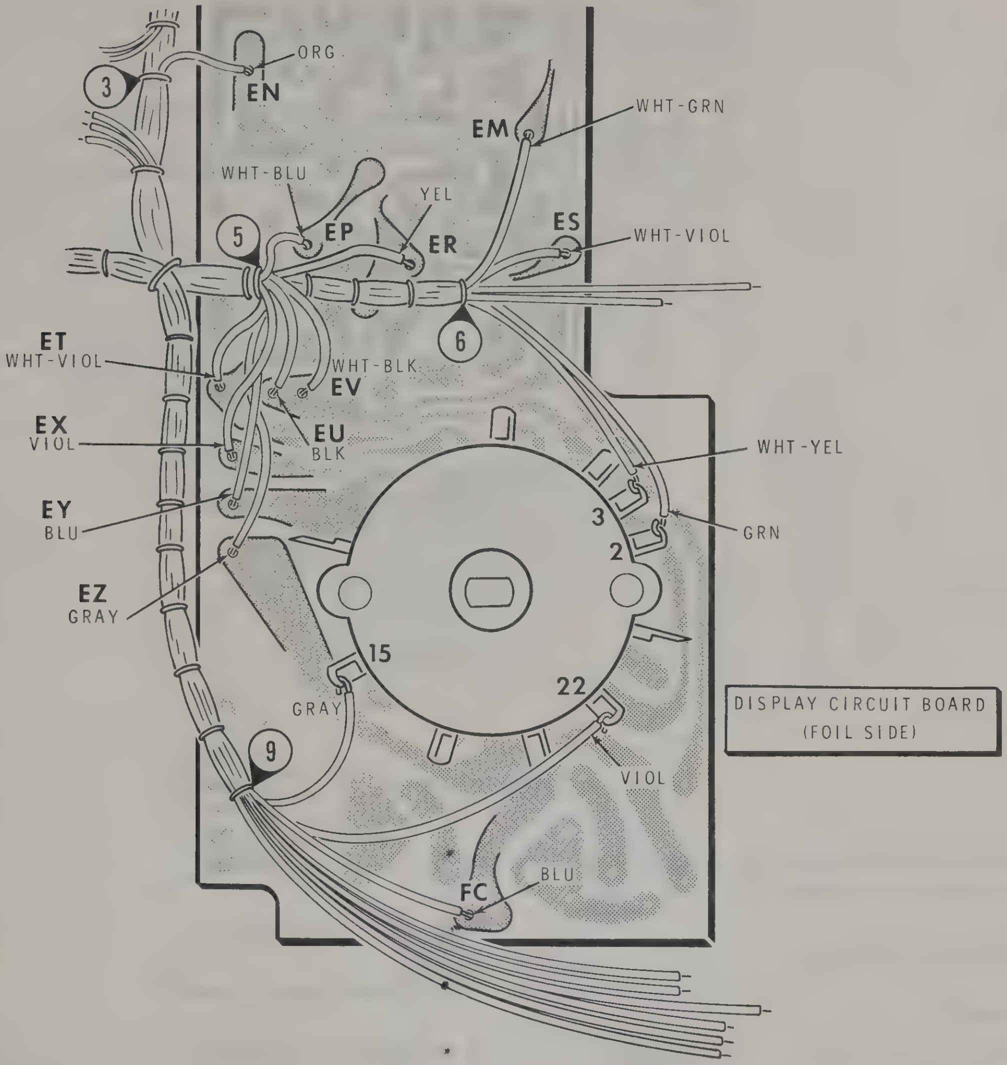
Connect the wires coming from BO#5 to the circuit board as follows:

(•) White-blue to hole EP.

(•) Yellow to hole ER.

(•) White-violet to hole ET.

(•) Black to hole EU.



PICTORIAL 4-3

(✓) White-black to hole EV.

(✓) Violet to hole EX.

(✓) Blue to hole EY.

(✓) Gray to hole EZ.

Connect the wires coming from BO#6 as follows:

(✓) White-violet to hole ES.

(✓) White-green to hole EM.

NOTE: For illustration purposes, only the two front wafers of the rotary switch are shown in the Pictorial.

(✓) White-yellow to rotary switch lug 3.

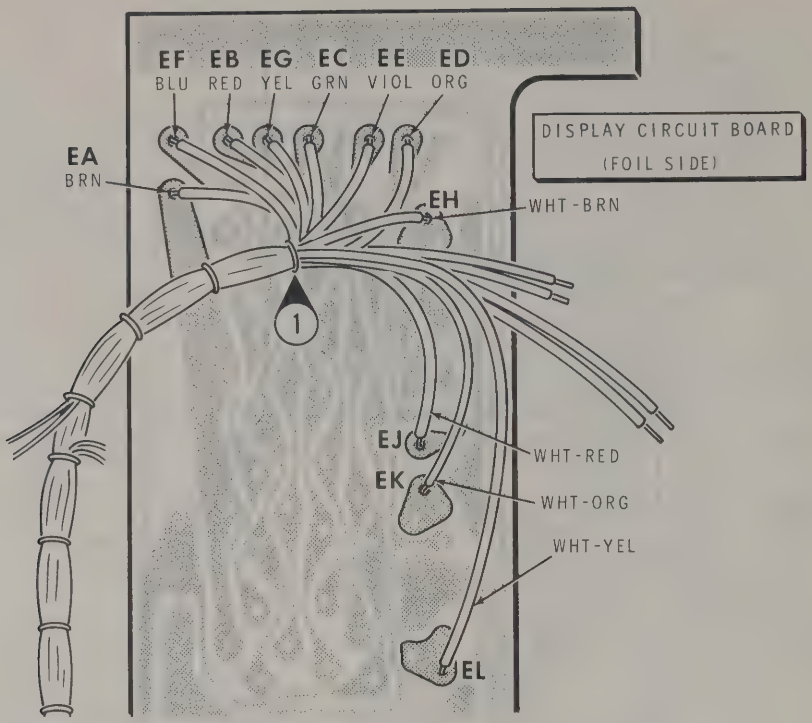
(✓) Green to rotary switch lug 2.

Connect the wires coming from BO#9 as follows:

(✓) Gray to rotary switch lug 15.

(✓) Violet to rotary switch lug 22.

(✓) Blue to hole FC.



PICTORIAL 4-4

Refer to Pictorial 4-4 and connect the wires coming from BO#1 to the circuit board as follows:

Solder each wire as you connect it.

(✓) Blue to hole EF.

(✓) Red to hole EB.

(✓) Yellow to hole EG.

(✓) Green to hole EC.

(✓) Violet to hole EE.

(✓) Orange to hole ED.

(✓) Brown to hole EA.

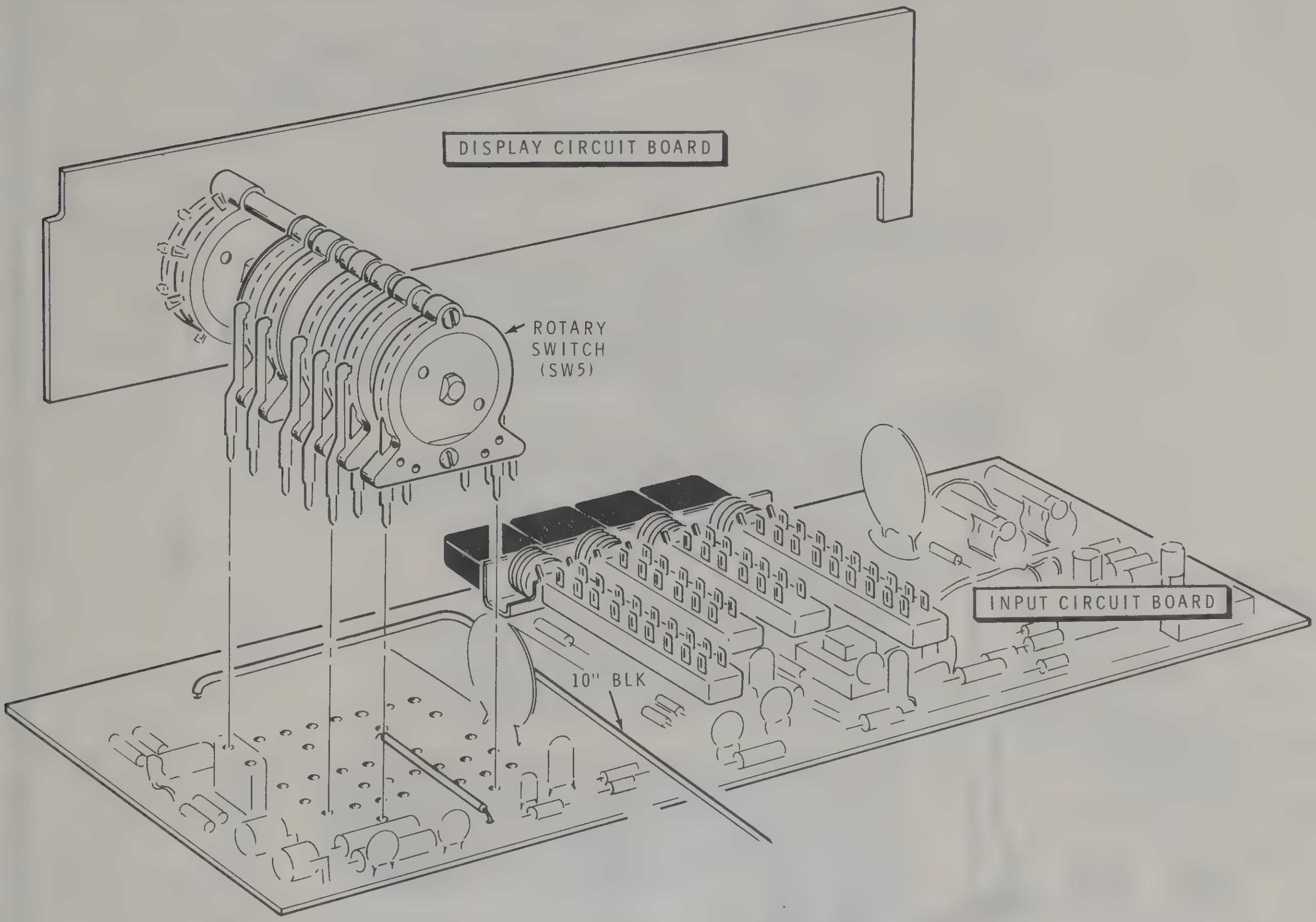
(✓) White-brown to hole EH.

(✓) White-red to hole EJ.

(✓) White-orange to hole EK.

(✓) White-yellow to hole EL.

(✓) Turn the circuit board over and cut off any excess wire lengths on the component side.



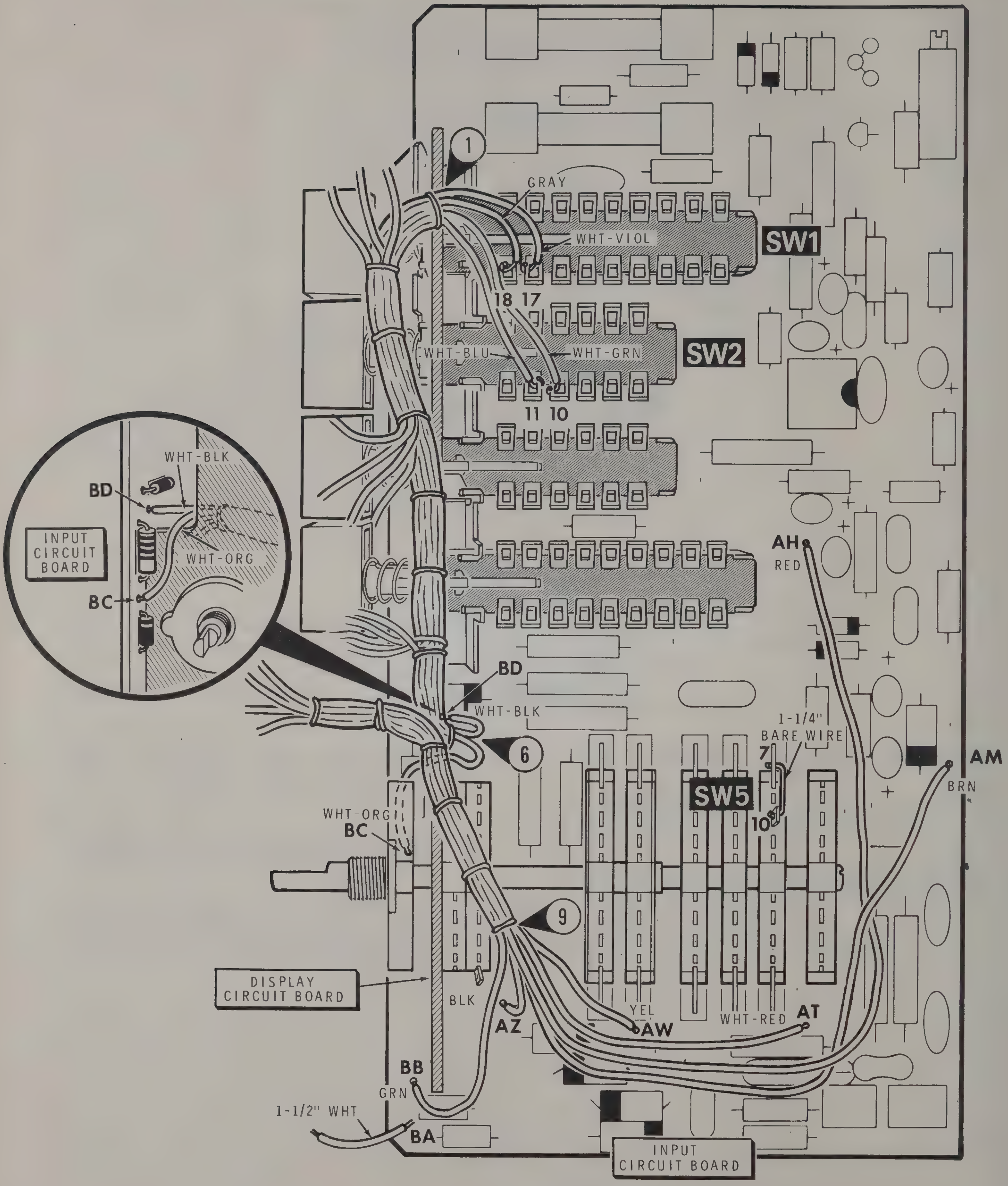
PICTORIAL 4-5

Refer to Pictorial 4-5 for the following steps.

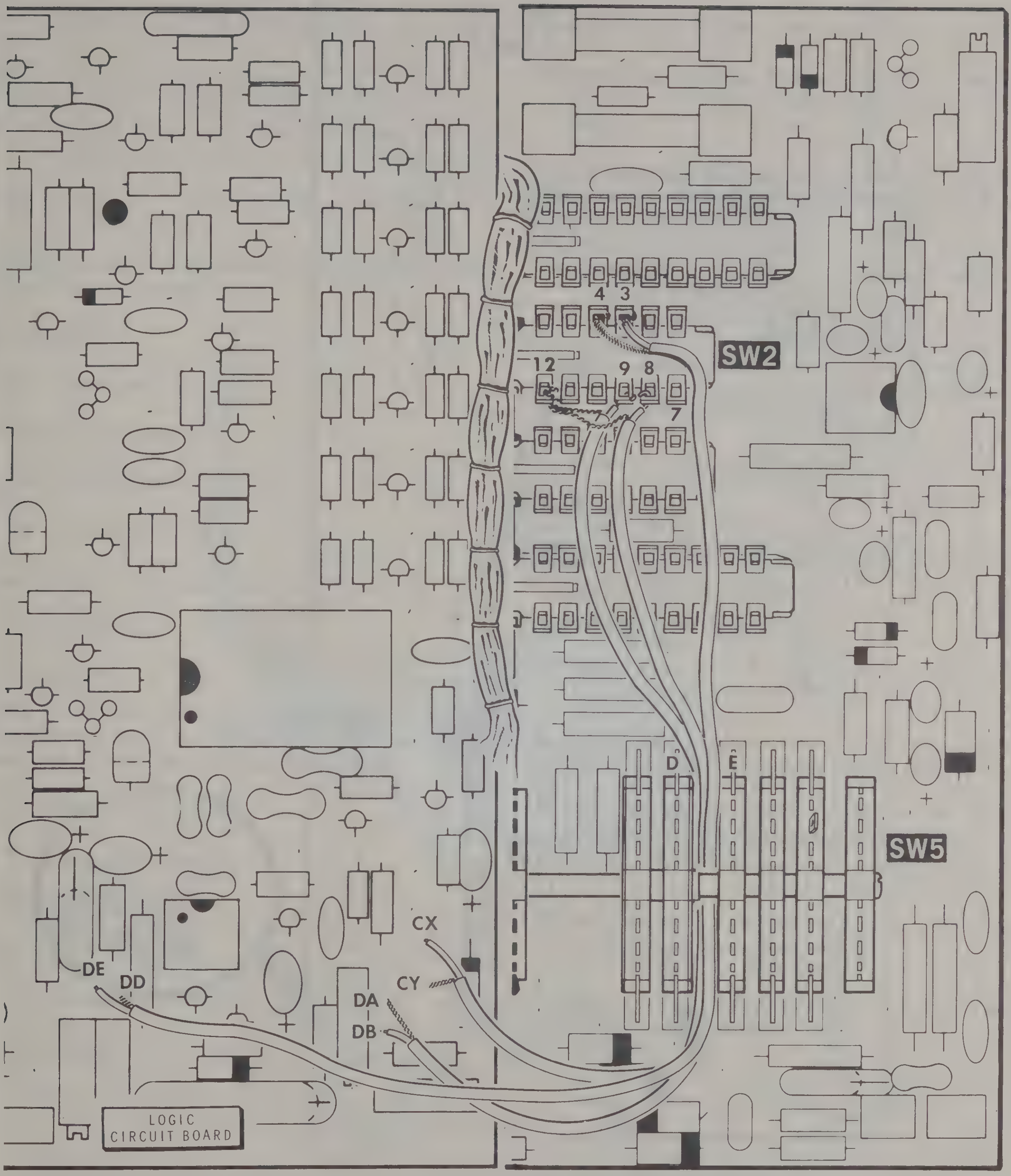
(✓) Position the 10" black wire, coming from hole AY on the input circuit board, as shown in the Pictorial.

(✓) Mount the display circuit board on the input circuit board as follows:

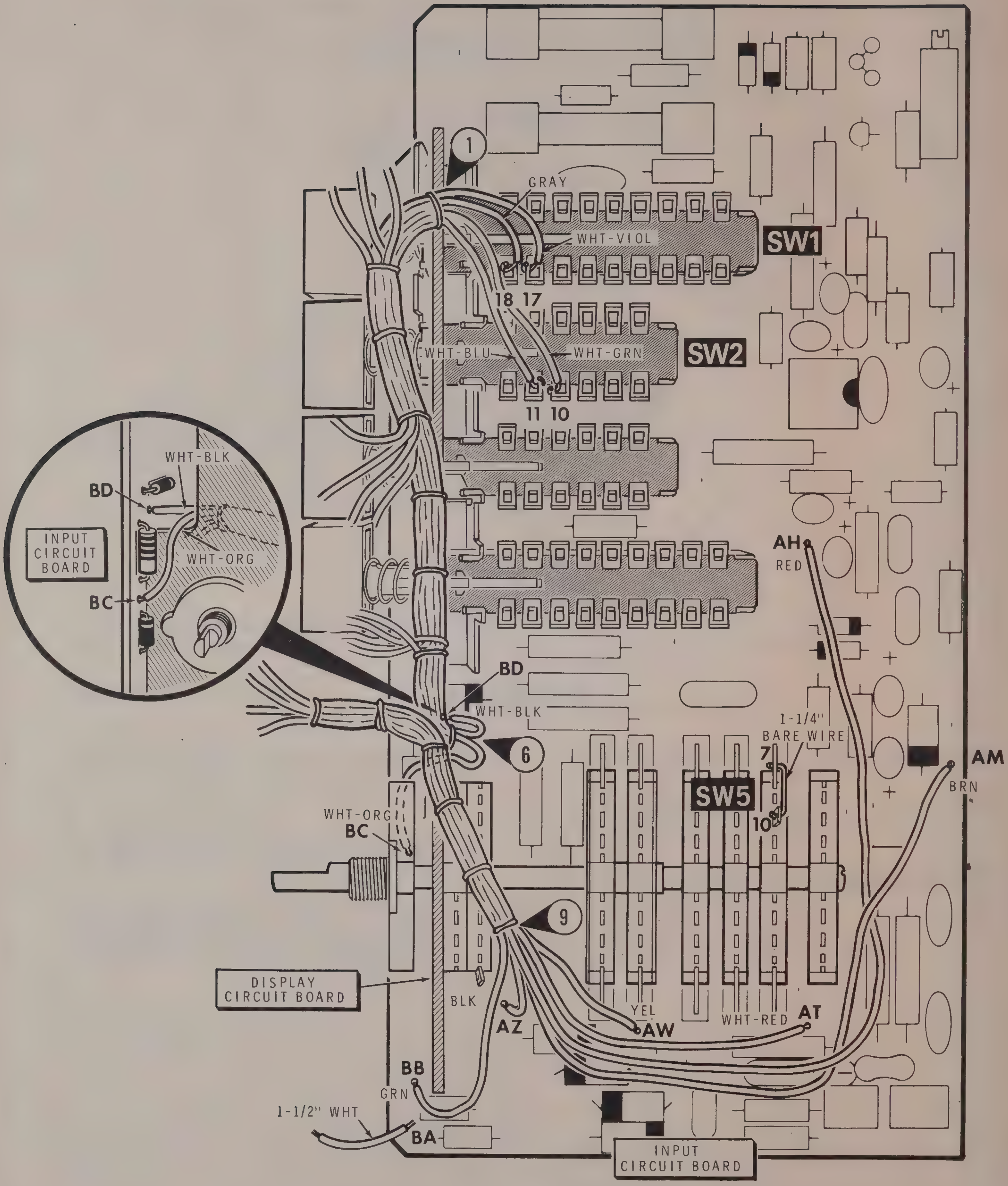
1. Make sure all the rotary switch (SW5) pins go through their respective holes as far as they will go.
2. Make sure the display circuit board is seated down against the input circuit board.
3. Make sure the switch pins do not pinch any wires under the switch.
4. Solder one switch pin to the foil at each corner. Then make sure the switch is straight, and solder the other pins.



PICTORIAL 4-6



PICTORIAL 4-8



PICTORIAL 4-6

Refer to Pictorial 4-6 for the following steps.

NOTE: In the following steps, solder each wire as you connect it and cut off any excess bare wire ends.

( ) Prepare a 1-1/2" white wire and connect one end to hole BA (S-1). The other end will be connected later.

( ) Connect a 1-1/4" bare wire between SW5 lug 7 (S-1) and SW5 lug 10 (S-1).

Connect the wires coming from the wire harness to the input circuit board as follows:

FROM BO#9:

( ) Green to hole BB.

( ) Black to hole AZ.

( ) Yellow to hole AW.

( ) White-red to hole AT.

( ) Brown to hole AM.

( ) Red to hole AH.

FROM BO#6:

Refer to the inset drawing and route the white-orange and white-black wires under the display circuit board and connect them to the input circuit board as follows:

( ) White-orange to hole BC.

( ) White-black to hole BD.

FROM BO#1:

( ) Gray to SW1 lug 18.

( ) White-violet to SW1 lug 17.

( ) White-blue to SW2 lug 11.

( ) White-green to SW2 lug 10.

Refer to Pictorial 4-7 for the following steps.

( ) Prepare two 5-1/4" lengths of shielded cable.

Connect one of the shielded cables as follows:

( ) At one end, connect the inner conductor to SW4 lug 14 (S-1) and the shield lead to circuit board hole AK (S-1).

( ) At the other end, cut off the shield lead and route the cable through SW5 between sections G and H as shown in the Pictorial.

( ) Connect the inner conductor of this cable to circuit board hole AV (S-1).

( ) At one end of the other shielded cable, connect the inner conductor to SW4 lug 3 (S-1) and the shield lead to circuit board hole AG (S-1). Note: The other hole close to hole AG will not be used.

( ) At the other end, cut off the shield lead and route the cable through SW5 between sections G and H as shown.

( ) Connect the inner conductor to circuit board hole AU (S-1).

( ) Prepare a 6-3/4" shielded cable.

( ) At one end, connect the inner conductor to SW2 lug 6 (S-1) and the shield lead to SW2 lug 4 (NS).

( ) At the other end, cut off the shield lead. Then route the cable through SW5 between sections G and H.

( ) Refer to the inset drawing and insert the inner conductor into the same hole with the indicated lug on the trimmer (C119).

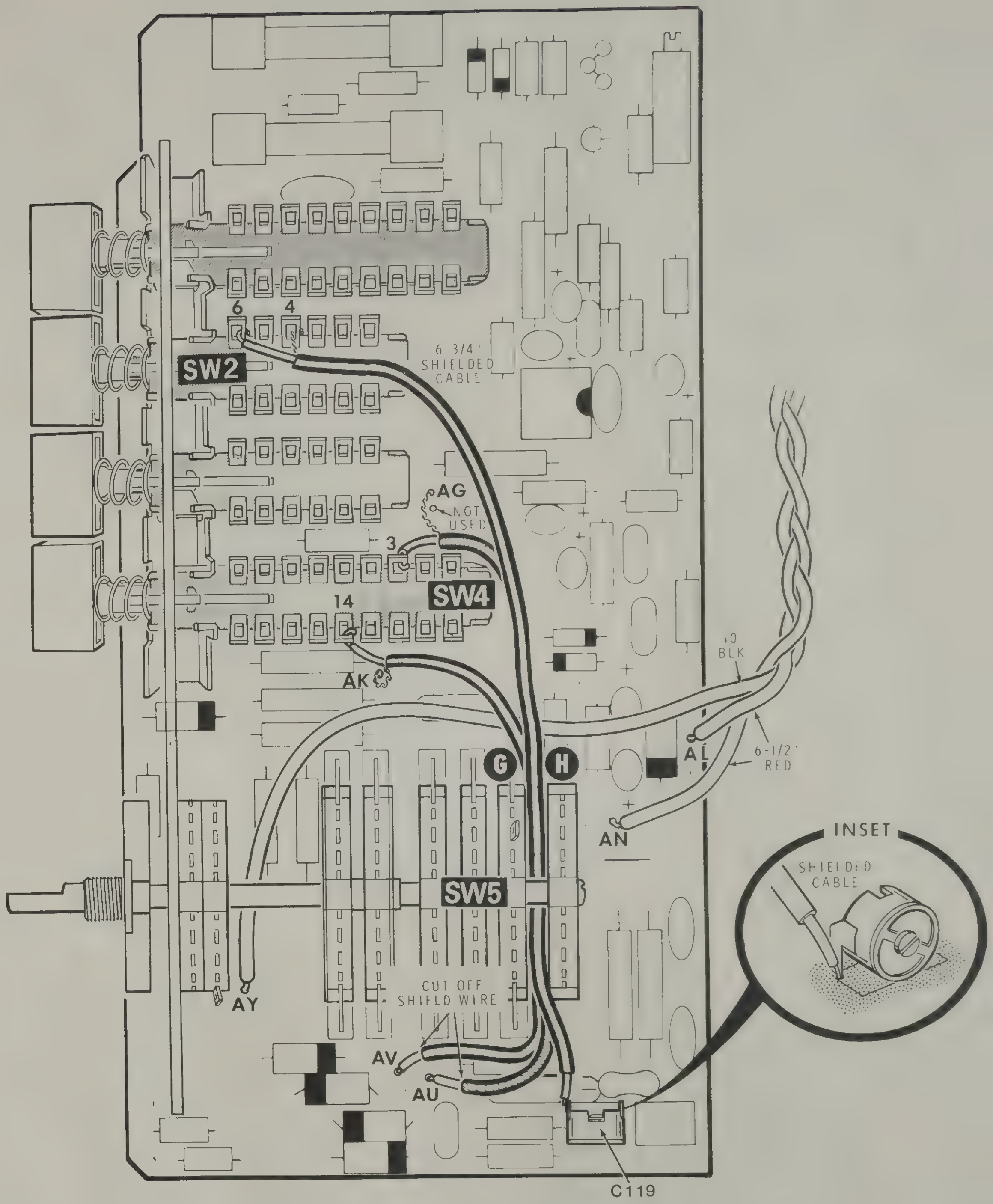
( ) Solder the inner conductor and both unsoldered lugs on the trimmer to the foil.

( ) Prepare a 6-1/2" red stranded wire and connect one end to circuit board hole AL (S-1).

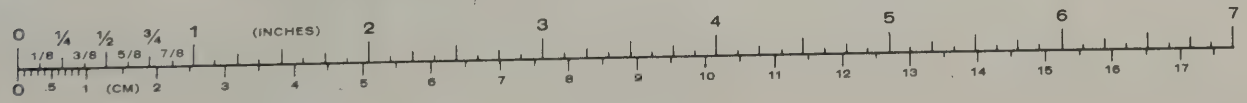
( ) Cut another 6-1/2" length of red stranded wire and remove 1/4" of insulation from one end only.

( ) Connect the bare end to hole AN (S-1).

( ) Twist the two red wires and the 10" black wire together about one turn per inch to form a twisted group as shown in the Pictorial.



PICTORIAL 4-7



Refer to Pictorial 4-8 for the following steps.

Prepare the following lengths of shielded cable by removing 3/4" of outer insulation from each end and then removing 1/4" of inner insulation from each end. The cables are listed in the order in which they will be used:

8"

7-1/2"

9"

( ) Position the logic circuit board as shown in the Pictorial.

Connect the shielded cables to SW2 and the logic circuit board as follows:

(●) 8" shielded cable: At one end, connect the inner conductor to SW2 lug 9 (S-1) and the shield lead to lug 12 (NS).

(●) Route the other end of the cable through SW5 between sections D and E as shown in the Pictorial.

(●) Connect the inner conductor to hole CX (S-1) and the shield lead to hole CY (S-1).

(●) 7-1/2" shielded cable: At one end, connect the inner conductor to SW2 lug 8 (S-1) and the shield lead to lug 12 (S-2).

(●) Route the other end through SW5 between sections D and E as before and connect the inner conductor to hole DB (S-1) and the shield lead to hole DA (S-1).

(●) 9" shielded cable: At one end, connect the inner conductor to SW2 lug 3 (S-1) and the shield lead to lug 4 (S-3).

(●) Route the other end through SW5 with the other two cables. Then connect the inner conductor to hole DE (S-1) and the shield lead to hole DD (S-1).

Refer to Pictorial 4-9 and connect the wires from the wire harness to the logic circuit board as follows. Solder each wire to the foil as you connect it and cut off any excess bare wire ends.

FROM BO#2:

(●) Brown to hole CA.

(●) Orange to hole CD.

(●) Blue to hole CH.

(●) Red to hole CB.

(●) Violet to hole CI.

(●) Green to hole CK.

FROM BO#3:

(●) Yellow to hole CG.

(●) Green to hole CC.

(●) Violet to hole CE.

(●) Gray to hole CJ.

(●) White-brown to hole CL.

(●) White-red to hole CM.

(●) White-orange to hole CN.

(●) White-yellow to hole CP.

FROM BO#4:

(●) Blue to hole CF.

(●) White-green to hole CS.

(●) Orange to hole CR.

(●) White-violet to hole CT.

FROM BO#7:

(●) White-yellow to hole CU.

(●) Red to hole CV.

(●) Blue to hole CW.

(●) Green to hole CZ.

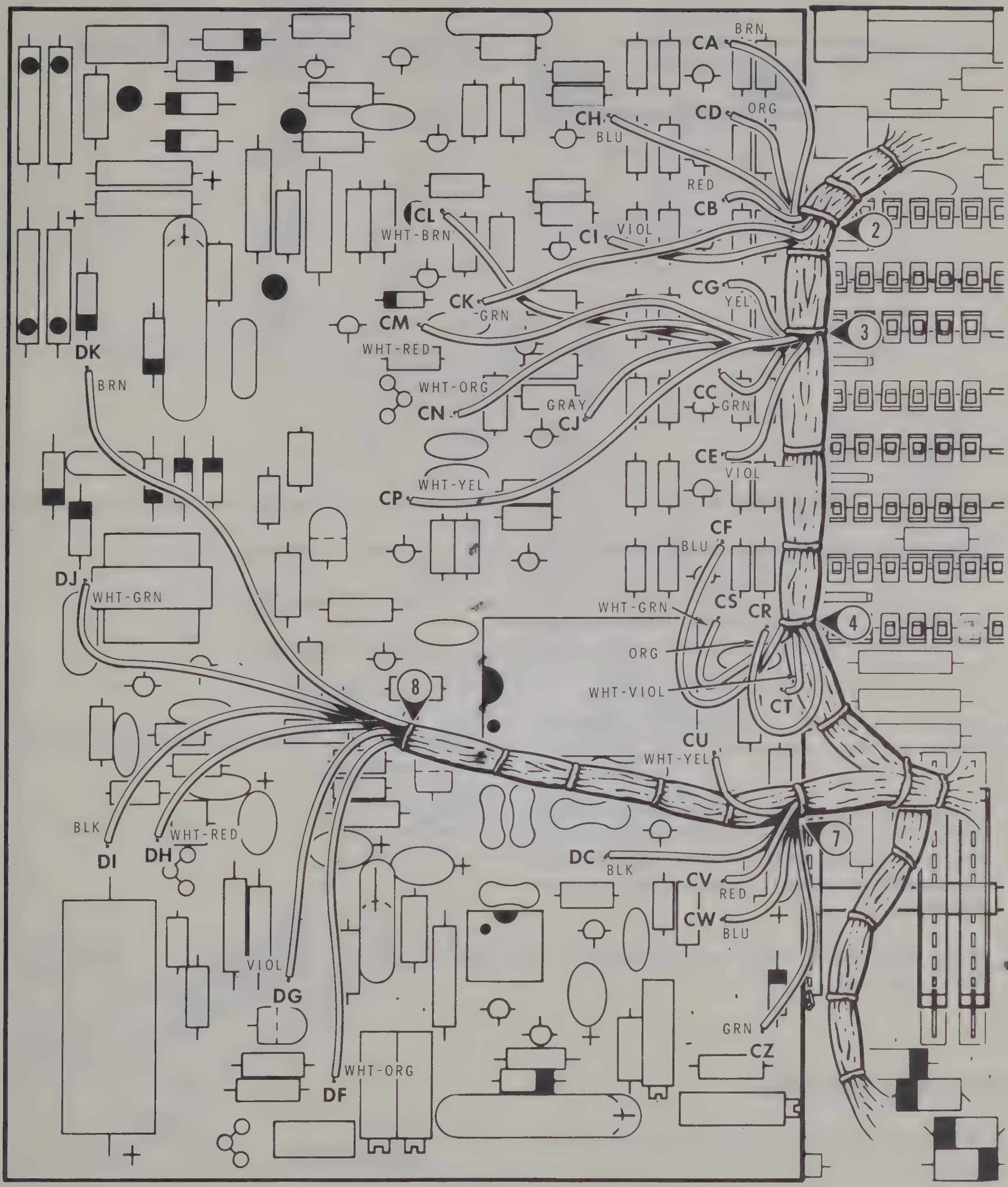
(●) Black to hole DC.

FROM BO#8:

(●) White-orange to hole DF.

CONTINUE

0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 .5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



PICTORIAL 4-9

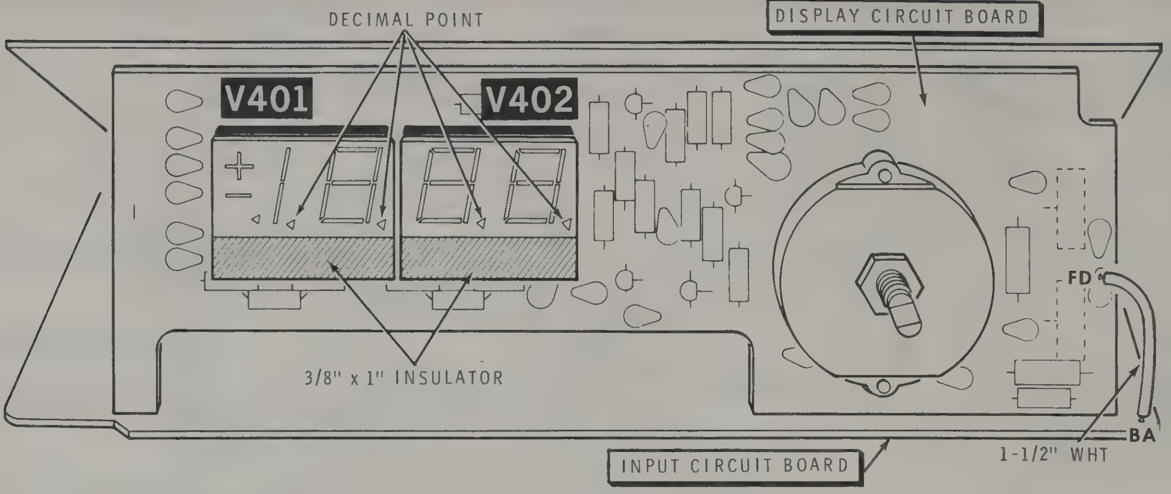
(●) Violet to hole DG.

(●) White-red to hole DH.

(●) Black to hole DI.

(●) White-green to hole DJ.

(●) Brown to hole DK.



PICTORIAL 4-10

Refer to Pictorial 4-10 for the following steps.

(✓) Position the assembled circuit boards as shown in the Pictorial.

(✓) Connect the 1-/2" white wire coming from hole BA on the input circuit board, to hole FD (S-1) on the display board.

(✓) Locate the two 3/8" x 1" pieces of cardboard insulator that you set aside earlier.

(✓) Remove the backing paper from one of the insulators. Then refer to the Pictorial and press the insulator into place on display tube V401. Position the top edge of the insulator just below the decimal point on the display tube.

(✓) In the same manner, install the other insulator on display tube V402.

FRONT PANEL ASSEMBLY

Refer to Pictorial 4-11 (fold-out from Page 63) for the following steps.

Locate the following items to be assembled in this Pictorial:

(✓) Front panel.

(✓) Display window.

(✓) Input jacks (red, white, and black) with attached nuts.

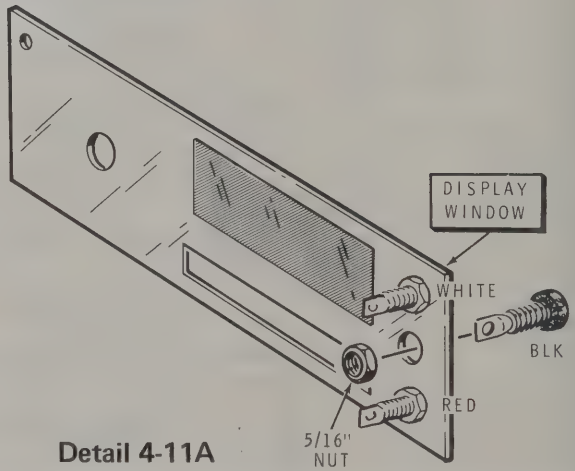
(✓) One of the two mounting brackets.

(✓) Three 5/16" lockwashers.

(✓) Three 5/16" flat washers.

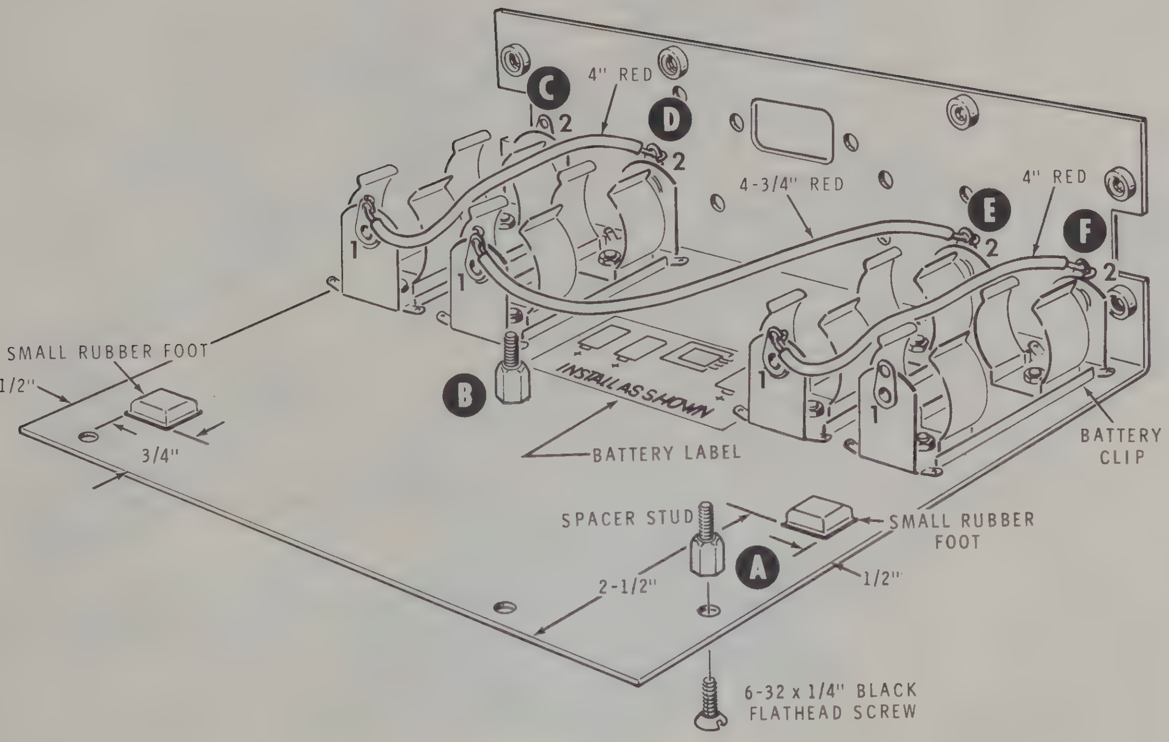
(✓) Three 5/16" nuts.

(✓) Peel off the protective coating from both sides of the display window.

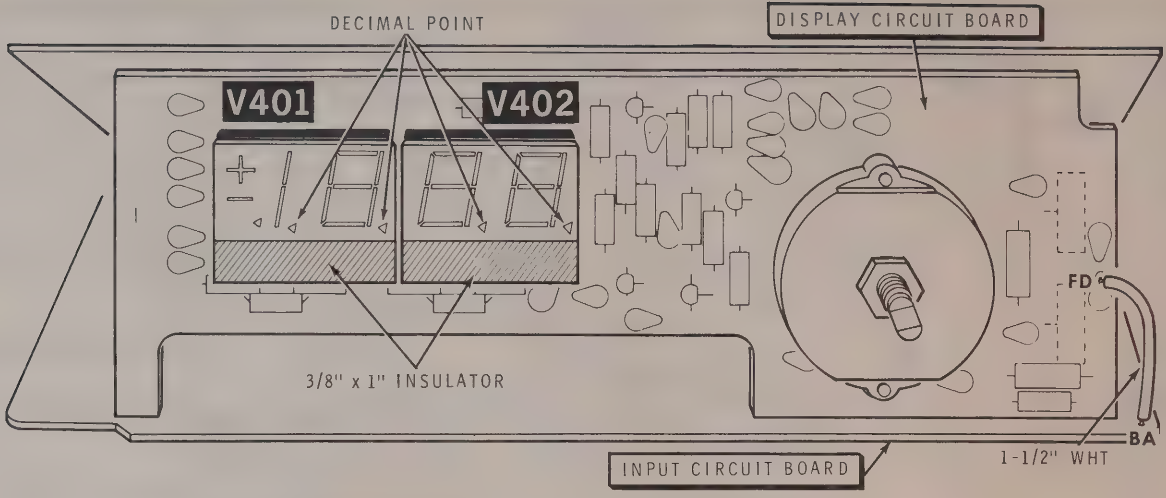


Detail 4-11A

(✓) Remove the attached mounting nuts from the three input jacks, and lay them aside; they will be used later to install the mounting bracket. Then, install the jacks in the display window with 5/16" nuts as shown in Detail 4-11A.



PICTORIAL 4-13



PICTORIAL 4-10

Refer to Pictorial 4-10 for the following steps.

(✓) Position the assembled circuit boards as shown in the Pictorial.

(✓) Connect the 1-/2" white wire coming from hole BA on the input circuit board, to hole FD (S-1) on the display board.

(✓) Locate the two 3/8" x 1" pieces of cardboard insulator that you set aside earlier.

(✓) Remove the backing paper from one of the insulators. Then refer to the Pictorial and press the insulator into place on display tube V401. Position the top edge of the insulator just below the decimal point on the display tube.

(✓) In the same manner, install the other insulator on display tube V402.

FRONT PANEL ASSEMBLY

Refer to Pictorial 4-11 (fold-out from Page 63) for the following steps.

Locate the following items to be assembled in this Pictorial:

(✓) Front panel.

(✓) Display window.

(✓) Input jacks (red, white, and black) with attached nuts.

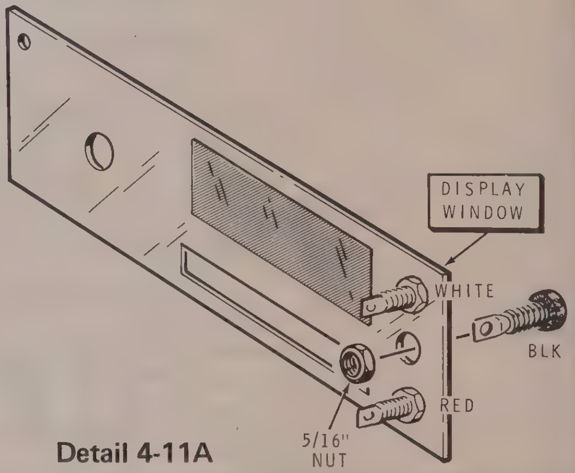
(✓) One of the two mounting brackets.

(✓) Three 5/16" lockwashers.

(✓) Three 5/16" flat washers.

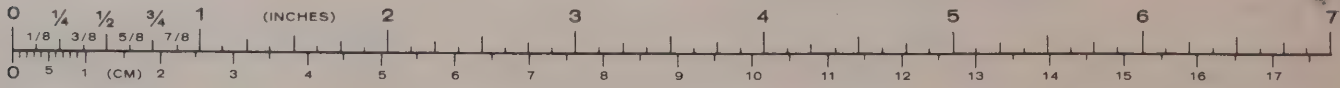
(✓) Three 5/16" nuts.

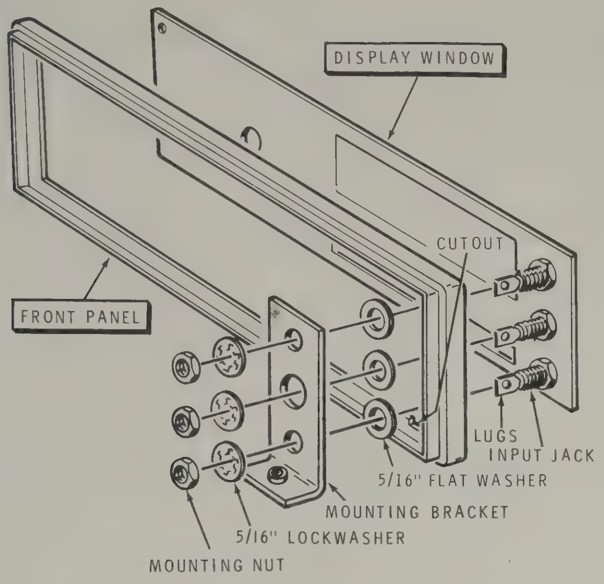
(✓) Peel off the protective coating from both sides of the display window.



Detail 4-11A

(✓) Remove the attached mounting nuts from the three input jacks, and lay them aside; they will be used later to install the mounting bracket. Then, install the jacks in the display window with 5/16" nuts as shown in Detail 4-11A.


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



Detail 4-11B

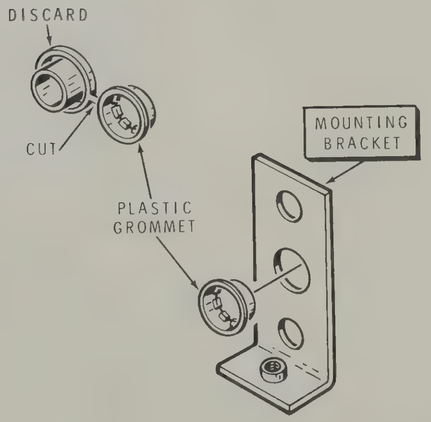
Refer to Detail 4-11B and mount the display window to the front panel as follows:

- (✓) Position the front panel with the cutout as shown in the Pictorial.
- (✓) Position the display window inside the front panel and place a 5/16" flat washer over each input jack.
- (✓) Position the mounting bracket on the input jacks as shown. Then fasten the bracket to the front panel with a 5/16" lockwasher and a mounting nut on each jack. Use the mounting nuts you saved from the input jacks. Do not overtighten the mounting nuts.

(✓) Locate the other mounting bracket and the plastic grommet.

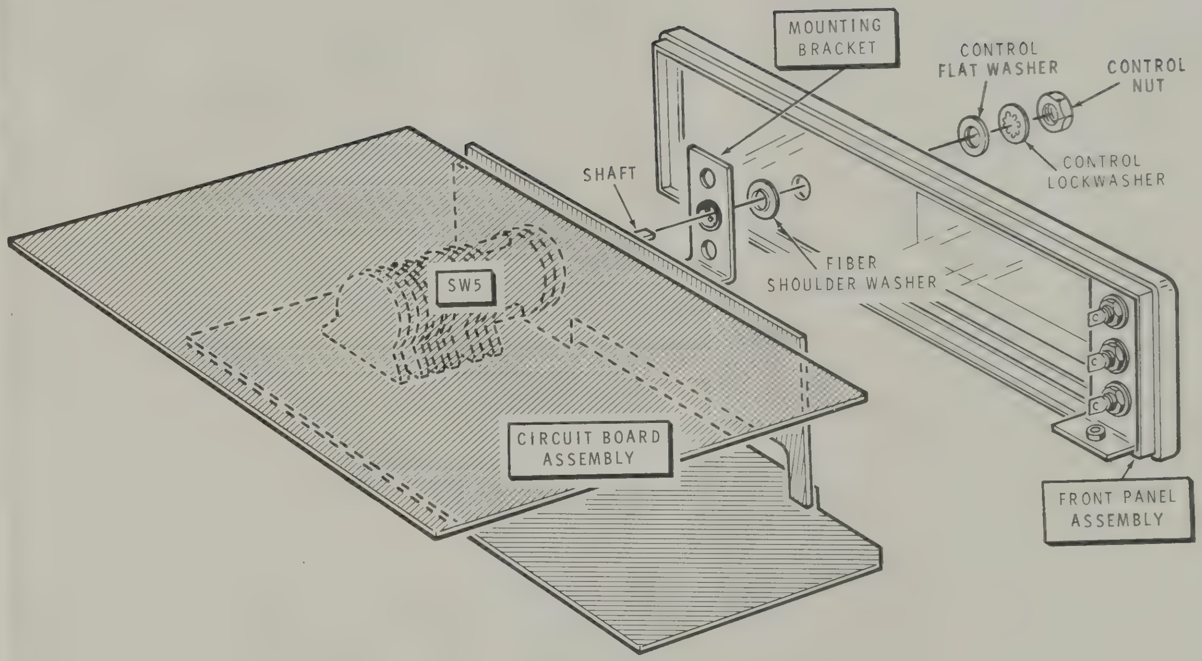
(✓) Cut the plastic grommet as shown in Detail 4-11C and discard the large part of the grommet; it will not be used. Then, install the small part of the grommet in the center hole of the mounting bracket as shown.

(✓) Position the circuit board assembly and the mounting bracket as shown in Pictorial 4-11, and install the bracket on the shaft of SW5.

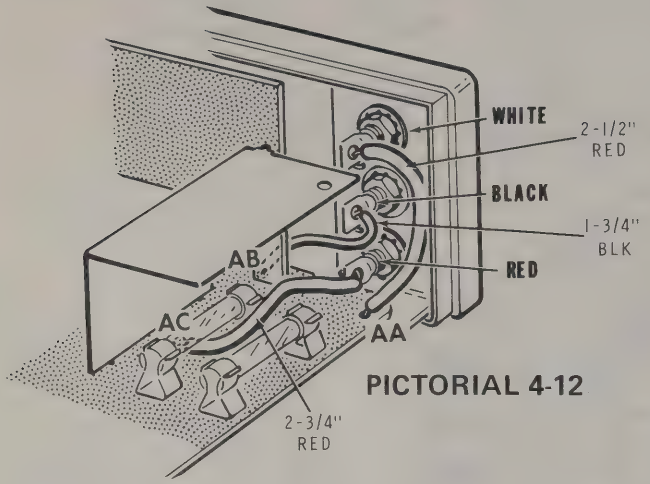


Detail 4-11C

(✓) Place the fiber shoulder washer on the shaft of SW5 so the shoulder faces away from the mounting bracket. Then mount the front panel assembly to the circuit board assembly with a 3/8" control flat washer, a 3/8" control lockwasher, and a 3/8" control nut.



PICTORIAL 4-11



PICTORIAL 4-12

Refer to Pictorial 4-12 for the following steps.

Connect the wires from the input circuit board to the input jacks as follows:

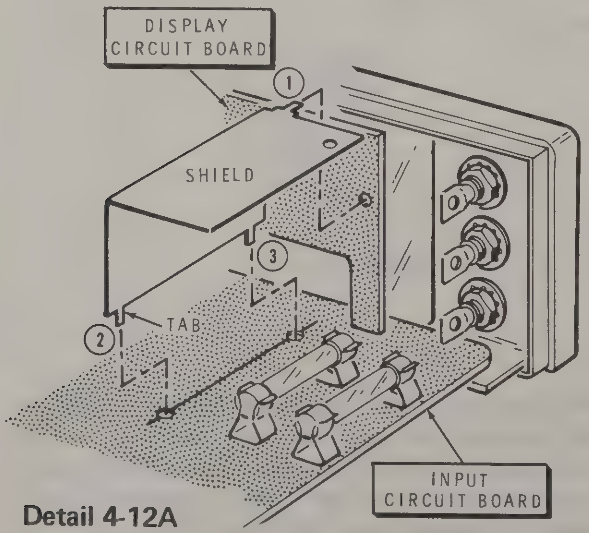
(✓) 2-3/4" red wire coming from hole AC to the red input jack (S-1).

(✓) 1-3/4" black wire coming from hole AB to the black input jack (S-1).

(✓) 2-1/2" red wire coming from hole AA to the white input jack (S-1). Position all wires as shown in the Pictorial.

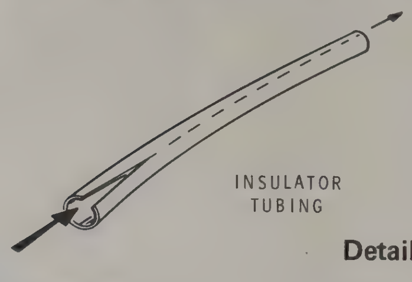
(✓) Locate the shield. Then, refer to Detail 4-12A and insert the shield tabs into the circuit board holes as shown.

(✓) Solder tab 1 to the display circuit board foil. Then turn the circuit board assembly over and solder tabs 2 and 3 to the foil on the input circuit board.



Detail 4-12A

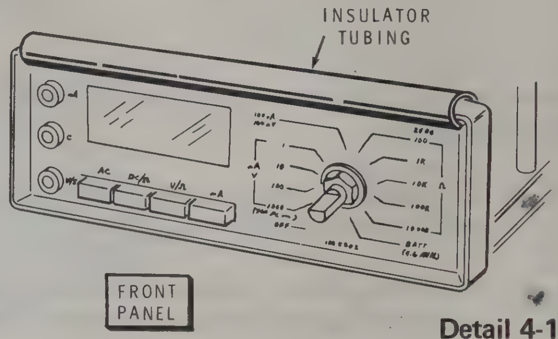
(✓) Locate the length of insulator tubing and cut the tubing along its entire length as shown in Detail 4-12B.



Detail 4-12B

(✓) Refer to Detail 4-12C and place the tubing on the top edge of the front panel. NOTE: If at any time, you service your multimeter or tilt the logic circuit board back against the front panel for any reason, always make sure you place the insulator tubing on the edge of the front panel. This will prevent any foils on the circuit board from being shorted to the metal front panel and prevent the front panel from being scratched.

Set the circuit board assembly aside.

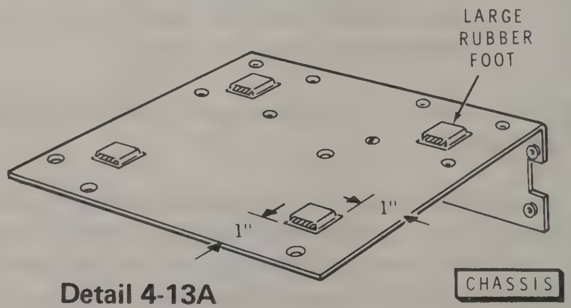


Detail 4-12C

CHASSIS ASSEMBLY AND WIRING

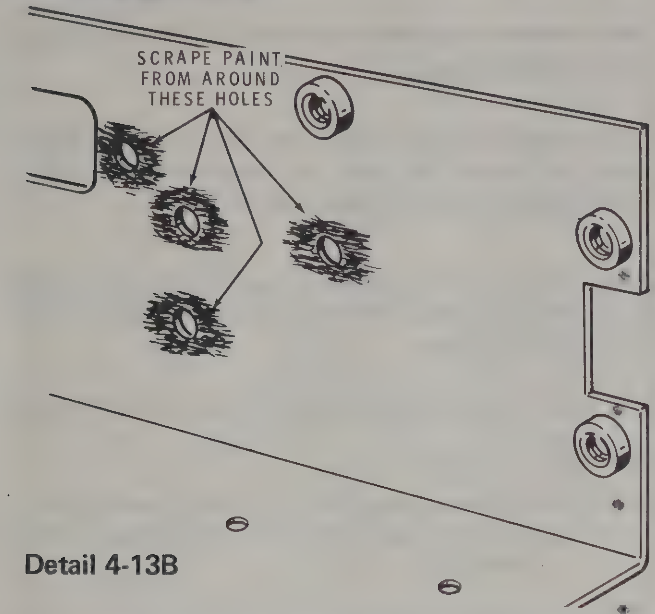
Refer to Pictorial 4-13 (fold-out from this page) for the following steps.

(✓) Locate the chassis and the four large rubber feet.



Detail 4-13A

(✓) Remove the backing paper from one of the rubber feet and press the foot into place 1" from each edge on the bottom of the chassis as shown in Detail 4-13A.



Detail 4-13B

(✓) In the same manner, install the other three rubber feet on the chassis bottom.

(✓) Refer to Detail 4-13B and scrape off the paint from around the four indicated holes on the inside of the rear of the chassis.

(✓) Position the chassis as shown in Pictorial 4-13.

(✓) Locate the two small rubber feet. Then remove the backing paper from one and press the foot into place on the chassis 2-1/2" from the front edge and 1/2" from the side as shown in the Pictorial.

(✓) Remove the backing paper from the other rubber foot and press the foot into place 3/4" from the front edge and 1/2" from the side as shown in the Pictorial.

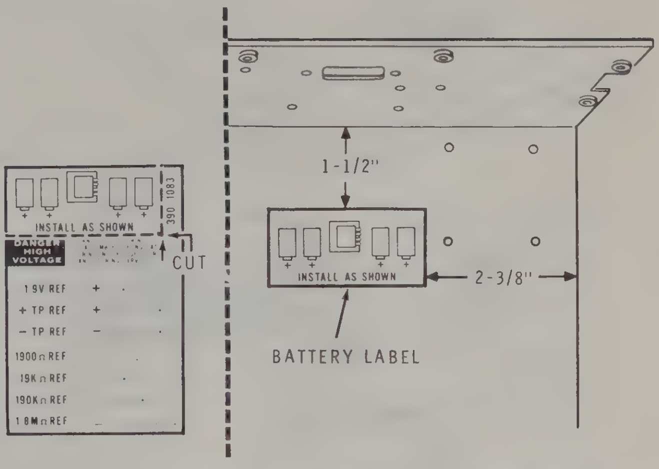
(✓) Refer to Detail 4-13C and cut the battery label from the label card. Then remove the backing paper and press the label into place on the chassis 2-3/8" from the side and 1-1/2" from the rear.

(✓) Install spacer studs at locations A and B with 6-32 x 1/4" black flat head screws.

(✓) Turn both lugs on each of the four battery clips so they point up as shown in Detail 4-13D.

NOTE: In the following steps, use the plastic nut starter to hold and start 6-32 nuts.

(✓) Refer to Detail 4-13D and mount the four battery clips at locations C, D, E, and F. Use two 6-32 x 1/4" black screws, two #6 black lockwashers and two 6-32 nuts for each battery clip.



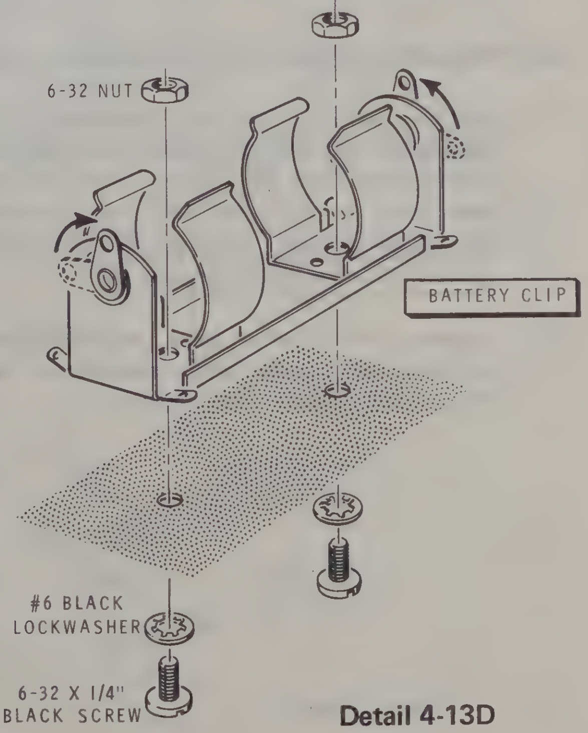
Detail 4-13C

NOTE: When you connect the wires to the battery clip lugs in the following steps, make sure the bare wire ends do not touch any other part of the battery clip.

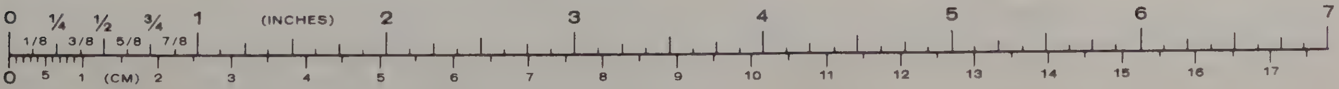
(✓) Connect a 4" red stranded wire between battery clip F lug 2 (S-1) and battery clip E lug 1 (S-1).

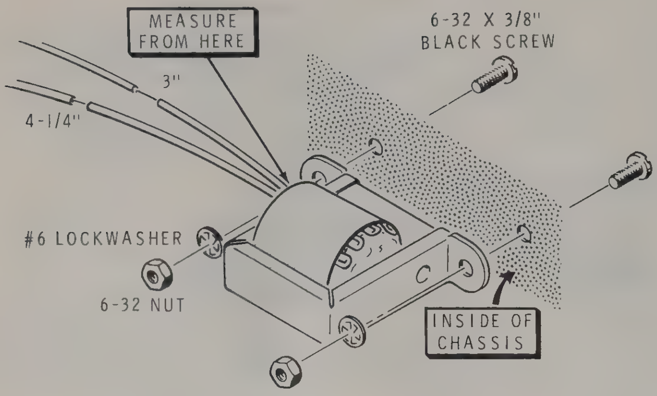
(✓) Connect a 4-3/4" red stranded wire between battery clip E lug 2 (S-1) and battery clip D lug 1 (S-1).

(✓) Connect a 4" red stranded wire between battery clip D lug 2 (S-1) and battery clip C lug 1 (S-1).



Detail 4-13D


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



Detail 4-14A

Refer to Pictorial 4-14 (fold-out from Page 67) for the following steps.

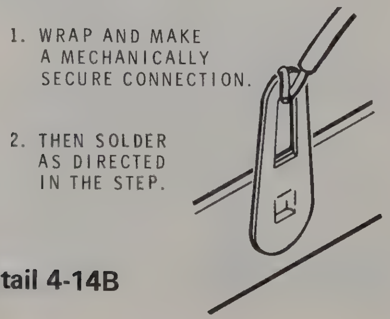
(●) Locate the power transformer. Then refer to Detail 4-14A and cut one of the transformer wires to a length of 3" and the other wire to a length of 4-1/4". Measure the wires from where they come out of the transformer. Then remove 1/4" of insulation from the end of each wire and melt a small amount of solder on the ends to hold the strands together.

(●) Mount the transformer at T1 with two 6-32 x 3/8" black screws, two #6 lockwashers, and two 6-32 nuts as shown in Detail 4-14A.

ALTERNATE POWER TRANSFORMER WIRING

1. NOTES: You can wire this multimeter to operate from either 120 VAC or 240 VAC line voltage. In the United States, 120 VAC is most often used, while in many other countries, 240 VAC is more common. In the following steps, use only the instructions that agree with the line voltage in your area.

2. In some of the following steps, you will be instructed to make mechanically secure connections. Refer to Detail 4-14B to make these connections.


1. WRAP AND MAKE A MECHANICALLY SECURE CONNECTION.
2. THEN SOLDER AS DIRECTED IN THE STEP.

Detail 4-14B

For 120 VAC Only

In the following steps, refer to the top portion of Pictorial 4-14 to connect the wires to transformer T1. Make a mechanically secure connection in each step.

(●) Remove 3/4" of insulation from the large red stranded wire. Then place this length of insulation on a 1-1/2" small bare wire.

(●) Connect the prepared wire between lugs 4 (NS) and 2 (S-1).

(●) Connect one end of a 1-1/4" black stranded wire to lug 4 (S-2). The other end of this wire will be connected later.

(●) Remove 3/4" of insulation from the large red stranded wire. Then place this length of insulation on a 1-1/2" small bare wire.

(●) Connect the prepared wire between lugs 3 (S-1) and 1 (NS).

(●) Connect one end of a 3" red stranded wire to lug 1 (S-2). The other end of this wire will be connected later.

For 240 VAC Only

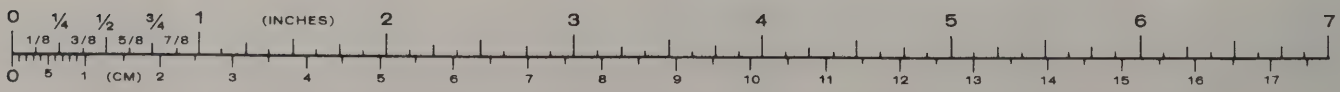
In the following steps, refer to the bottom portion of Pictorial 4-14 to connect the wires to transformer T1. Make a mechanically secure connection in each step.

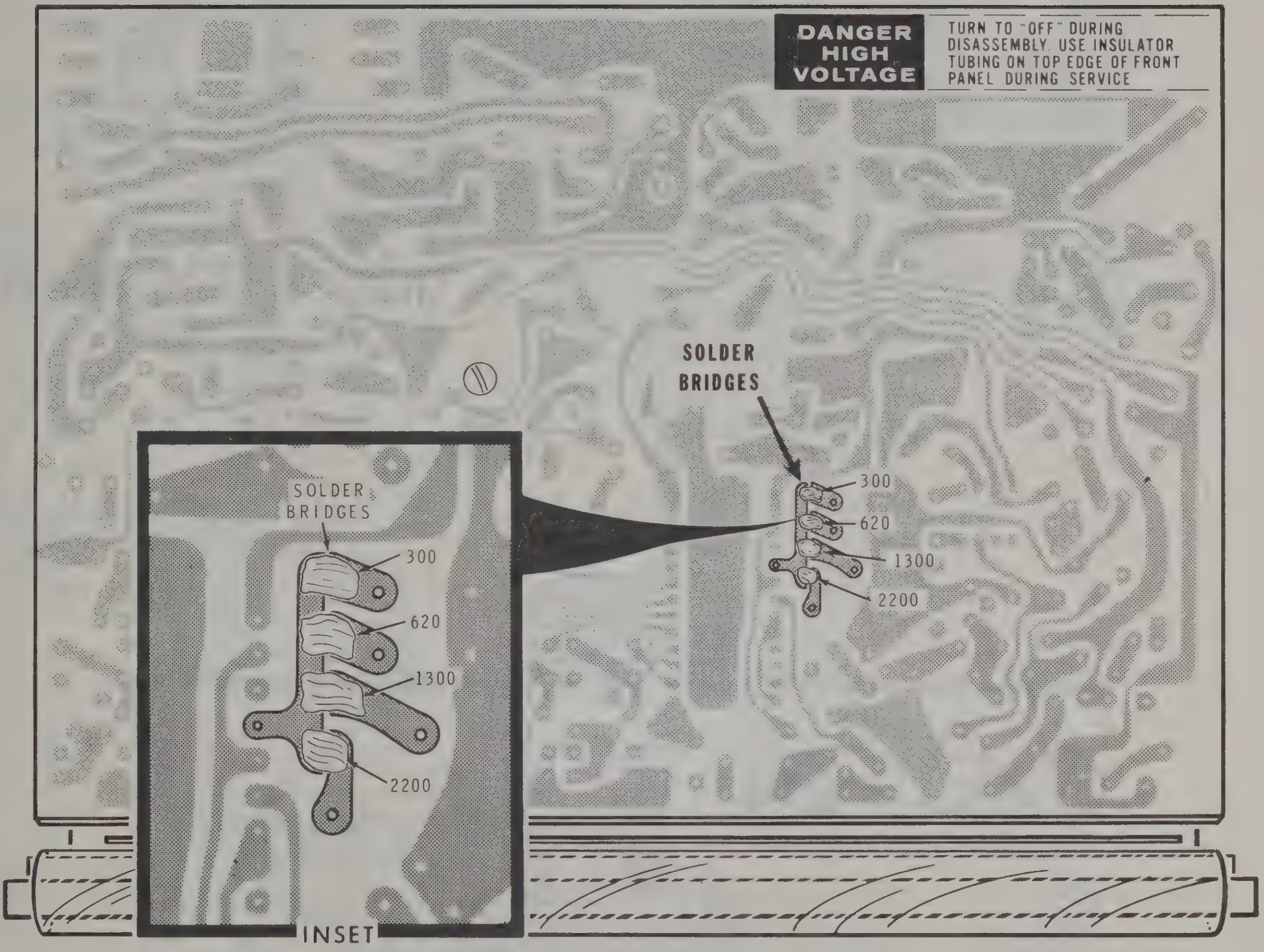
( ) Connect one end of a 1-1/4" black stranded wire to lug 4 (S-1). The other end of this wire will be connected later.

( ) Remove 3/4" of insulation from the large red stranded wire. Then place this length of insulation on a 1-1/2" small bare wire.

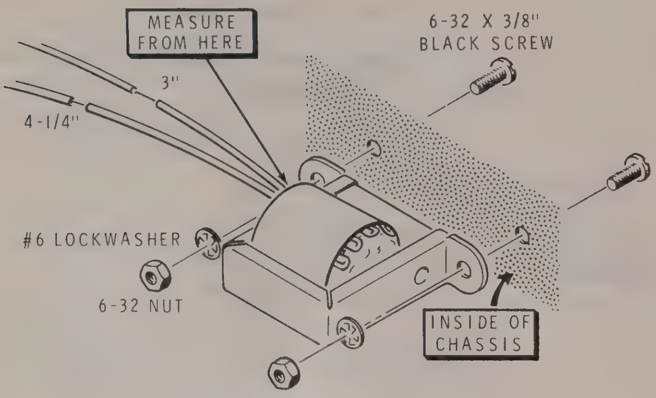
( ) Connect the prepared wire between lugs 3 (S-1) and 2 (S-1).

( ) Connect one end of a 3" red stranded wire to lug 1 (S-1). The other end of this wire will be connected later.


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17


DANGER HIGH VOLTAGE
TURN TO "OFF" DURING DISASSEMBLY. USE INSULATOR TUBING ON TOP EDGE OF FRONT PANEL DURING SERVICE
SOLDER BRIDGES
SOLDER BRIDGES
INSET

Detail 4-18B



Detail 4-14A

Refer to Pictorial 4-14 (fold-out from Page 67) for the following steps.

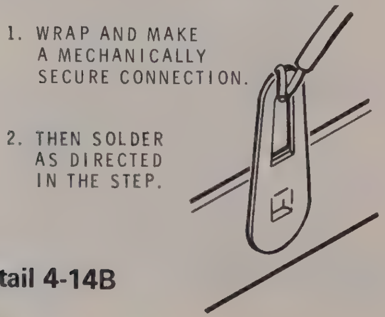
(•) Locate the power transformer. Then refer to Detail 4-14A and cut one of the transformer wires to a length of 3" and the other wire to a length of 4-1/4". Measure the wires from where they come out of the transformer. Then remove 1/4" of insulation from the end of each wire and melt a small amount of solder on the ends to hold the strands together.

(•) Mount the transformer at T1 with two 6-32 x 3/8" black screws, two #6 lockwashers, and two 6-32 nuts as shown in Detail 4-14A.

ALTERNATE POWER TRANSFORMER WIRING

1. NOTES: You can wire this multimeter to operate from either 120 VAC or 240 VAC line voltage. In the United States, 120 VAC is most often used, while in many other countries, 240 VAC is more common. In the following steps, use only the instructions that agree with the line voltage in your area.

2. In some of the following steps, you will be instructed to make mechanically secure connections. Refer to Detail 4-14B to make these connections.


1. WRAP AND MAKE A MECHANICALLY SECURE CONNECTION.
2. THEN SOLDER AS DIRECTED IN THE STEP.

Detail 4-14B

For 120 VAC Only

In the following steps, refer to the top portion of Pictorial 4-14 to connect the wires to transformer T1. Make a mechanically secure connection in each step.

(•) Remove 3/4" of insulation from the large red stranded wire. Then place this length of insulation on a 1-1/2" small bare wire.

(•) Connect the prepared wire between lugs 4 (NS) and 2 (S-1).

(•) Connect one end of a 1-1/4" black stranded wire to lug 4 (S-2). The other end of this wire will be connected later.

(•) Remove 3/4" of insulation from the large red stranded wire. Then place this length of insulation on a 1-1/2" small bare wire.

(•) Connect the prepared wire between lugs 3 (S-1) and 1 (NS).

(•) Connect one end of a 3" red stranded wire to lug 1 (S-2). The other end of this wire will be connected later.

For 240 VAC Only

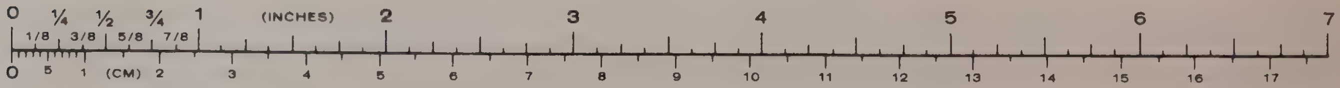
In the following steps, refer to the bottom portion of Pictorial 4-14 to connect the wires to transformer T1. Make a mechanically secure connection in each step.

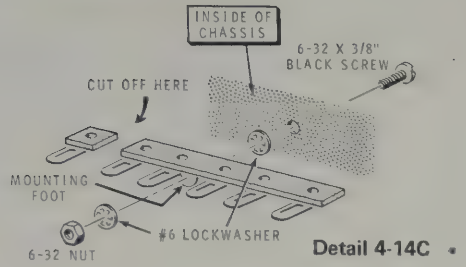
( ) Connect one end of a 1-1/4" black stranded wire to lug 4 (S-1). The other end of this wire will be connected later.

( ) Remove 3/4" of insulation from the large red stranded wire. Then place this length of insulation on a 1-1/2" small bare wire.

( ) Connect the prepared wire between lugs 3 (S-1) and 2 (S-1).

( ) Connect one end of a 3" red stranded wire to lug 1 (S-1). The other end of this wire will be connected later.



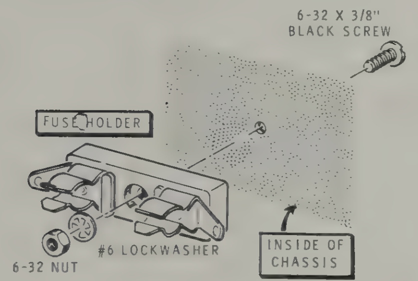


Detail 4-14C

Refer to Detail 4-14C for the next two steps.

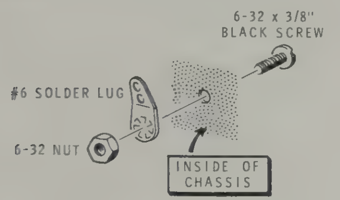
(✓) Locate the terminal strip and position it so the mounting foot faces down as shown in the Detail. Then cut off the indicated lug.

(✓) Mount the terminal strip at H with a 6-32 x 3/8" black screw, two #6 lockwashers, and a 6-32 nut.



Detail 4-14D

(✓) Refer to Detail 4-14D and install the fuseholder at F1 with a 6-32 x 3/8" black screw, a #6 lockwasher, and a 6-32 nut.



Detail 4-14E

(✓) Refer to Detail 4-14E and install a #6 solder lug at G. Use a 6-32 x 3/8" black screw and a 6-32 nut. Position the solder lug as shown in the Pictorial.

Refer to Pictorial 4-15 for the following steps.

(✓) Locate the AC socket. Then refer to Detail 4-15A and install the socket at J with two 6-32 x 3/8" black screws, two #6 lockwashers, and two 6-32 nuts. Make sure you position the socket so lug 1 is up as shown in the Pictorial.

(✓) Refer to the inset drawing on the Pictorial and place the fiber insulator over the lugs of the AC socket.

(✓) Connect the 1-1/4" black wire coming from transformer lug 4 to AC socket lug 3 (S-1). Make a mechanically secure connection.

(✓) Connect a 3-1/2" red stranded wire between AC socket lug 2 (S-1) and fuseholder lug 1 (S-1). Make a mechanically secure connection.

NOTE: In the following step, use the length of green wire supplied with this kit. Do not use a cutoff transformer wire.

(✓) Connect a 1-3/4" green wire between AC socket lug 1 (S-1) and solder lug G (S-1). Make a mechanically secure connection.

(✓) Connect the 3" red wire, coming from transformer lug 1 to fuseholder lug 2 (S-1). Make a mechanically secure connection.

(✓) Connect a 7-1/2" black stranded wire between battery clip C lug 2 (S-1) and terminal strip lug 3 (NS). Route the wire behind the battery clips and underneath the transformer as shown in the Pictorial.

(✓) Route the transformer wires as shown in the Pictorial. Then connect the 3" transformer wire to terminal strip H lug 1 (NS).

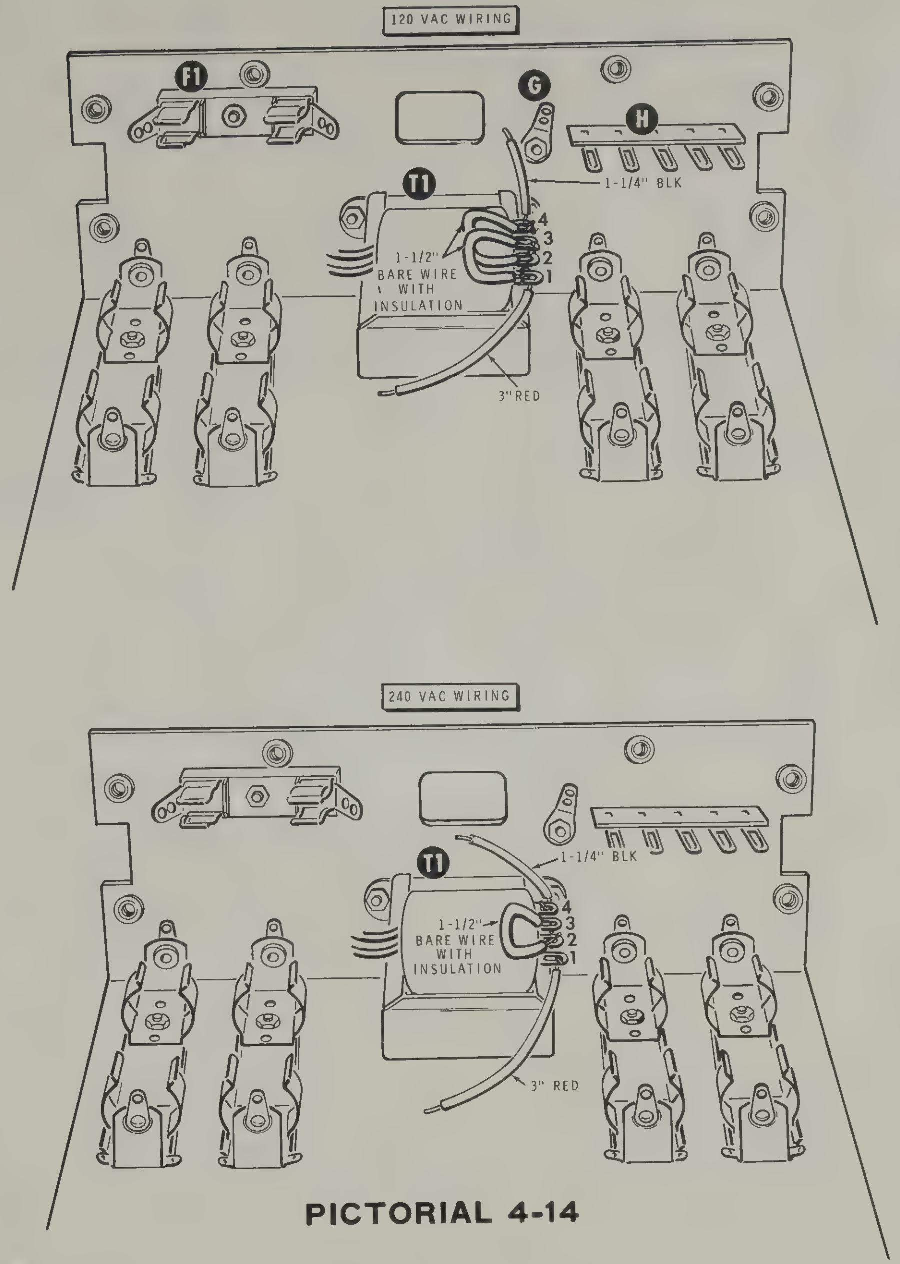
(✓) 4-1/4" transformer wire to terminal strip H lug 3 (NS).

(✓) Connect a 3-1/2" red wire between battery clip F lug 1 (S-1) and terminal strip lug 4 (NS).

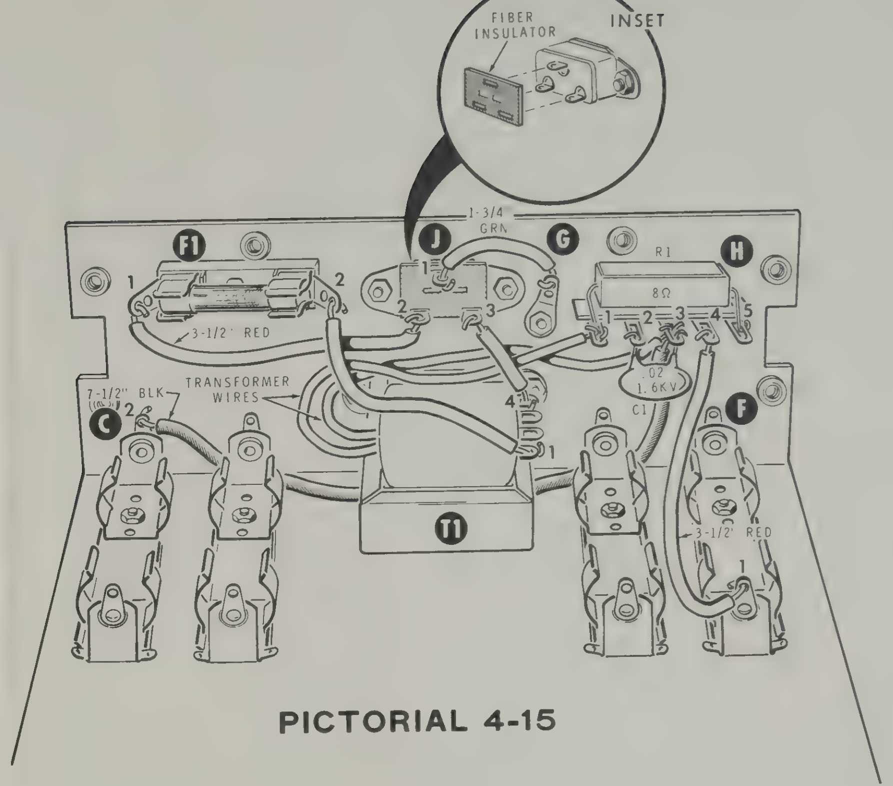
(✓) C1: Connect one lead of a .02 μF 1600 V (1.6 KV) capacitor to lug 2 of the terminal strip (S-1) and the other lead to lug 3 of the terminal strip (NS). Cut off any excess lead lengths.

(✓) R1: Connect one lead of an 8 Ω, 7-watt resistor to lug 1 of the terminal strip (S-2) and the other lead to lug 5 of the terminal strip (NS). Position the resistor on top of the terminal strip as shown in the Pictorial and cut off the excess lead lengths.

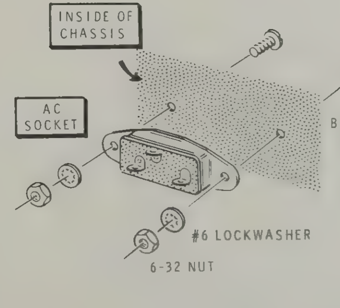
(✓) F1: Install the 1/8-ampere 3AG fuse (1/16-ampere for 240 VAC operation) in the fuseholder.



PICTORIAL 4-14



PICTORIAL 4-15



Detail 4-15A

Refer to Pictorial 4-16 for the following steps.

(✓) Position the chassis and the circuit board assembly as shown in the Pictorial and set the circuit board assembly down on the chassis so that the spacer studs go through the holes in the input circuit board.

(✓) Fasten the circuit board assembly to the chassis with two 6-32 x 1/4" black flat head screws at K and L. Make sure the screws fit properly into the two mounting brackets before you tighten the screws.

(✓) Locate the two 2" spacers and install them on the spacer studs as shown in the Pictorial.

(✓) Refer to the inset drawing and rotate switch SW5 so that the locating notch on the rear of the switch is positioned as shown.

Refer to Pictorial 4-17 for the following steps.

(✓) Refer to the Pictorial and to the battery installation label, and install the four batteries in the battery clips with the plus (+) marked end toward the front of the Multimeter.

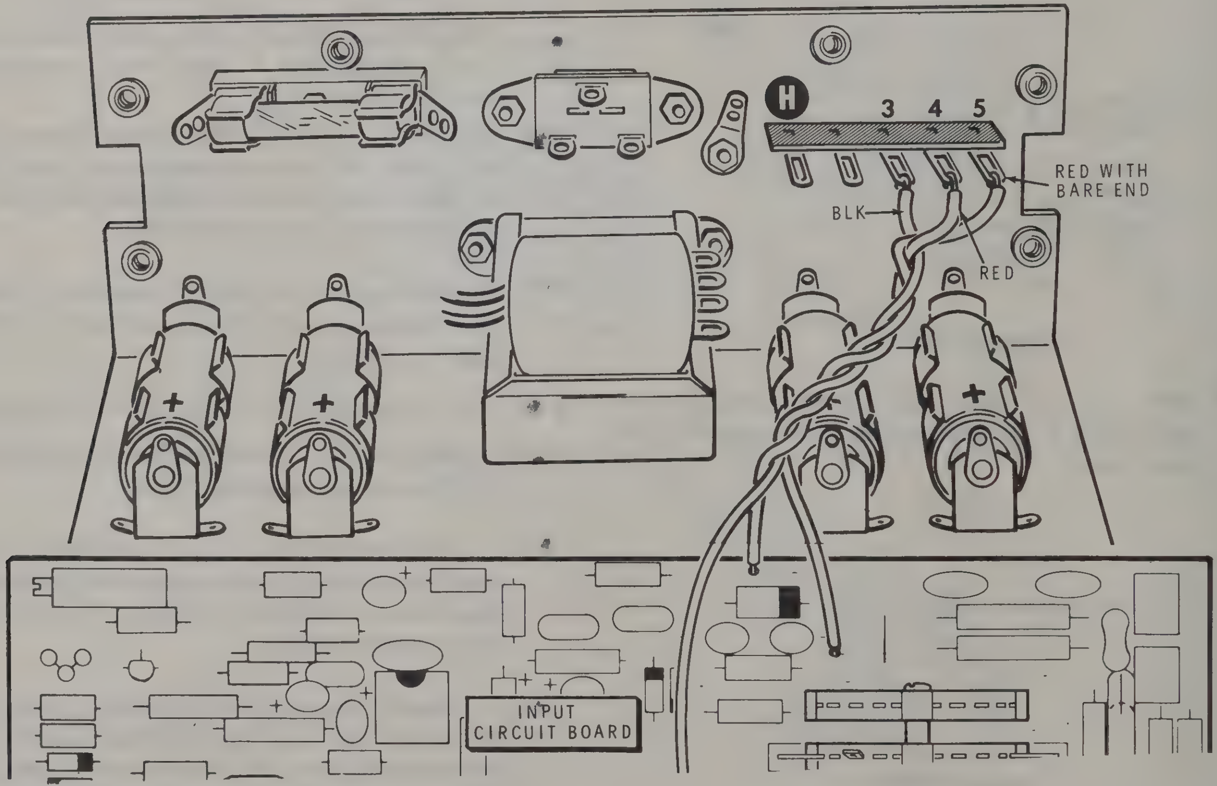
Position the assembled Multimeter as shown in the Pictorial and connect the twisted group of wires coming from the input circuit board to terminal strip H as follows:

(✓) Black to lug 3 (S-4).

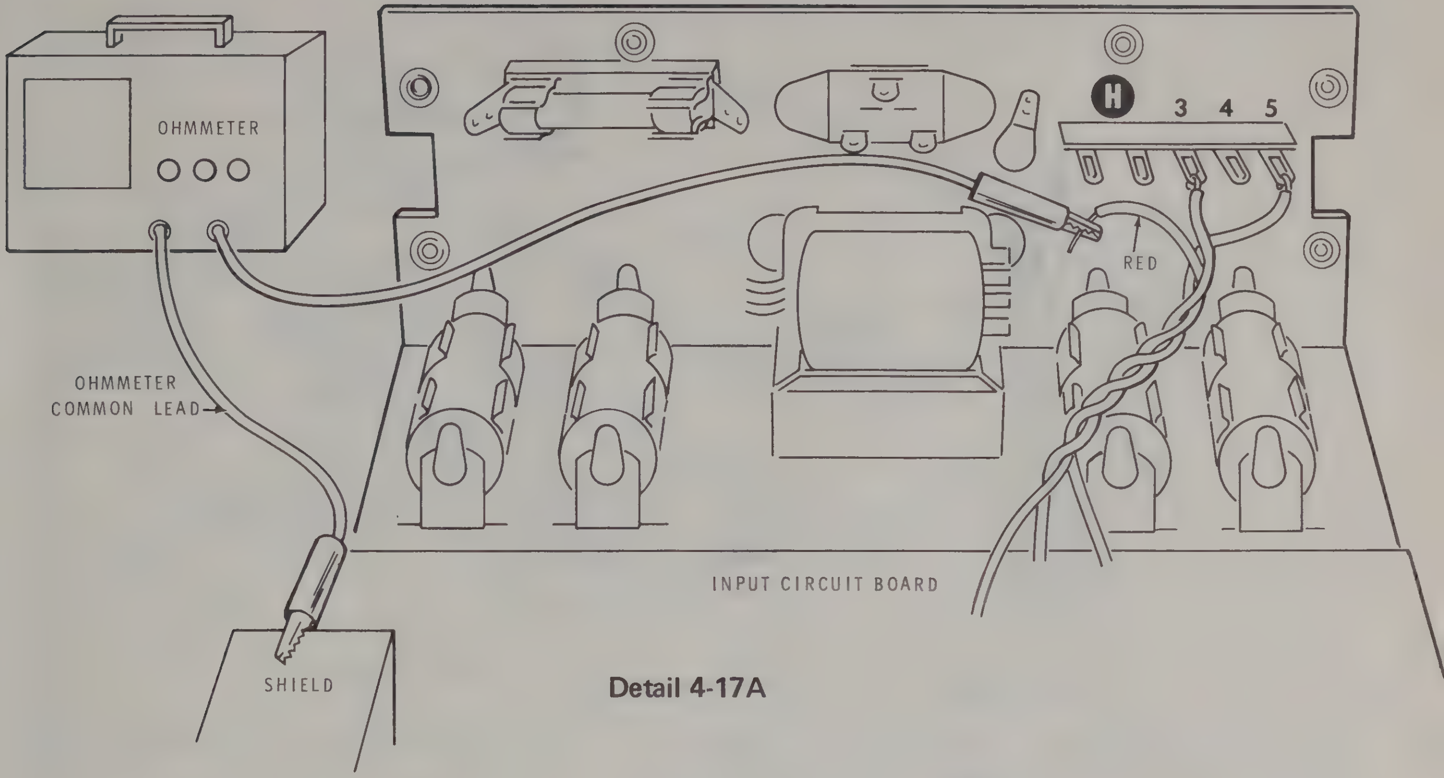
(✓) Red (with bare end) to lug 5 (S-2).

( ) Remove 1/4" of insulation from the free end of the other red wire in the twisted group.

NOTE: Steps 1 and 2 on the next page describe two methods for making a short-circuit test before you connect the red wire. If an ohmmeter is available, perform only step 1. If an ohmmeter is not available, perform only step 2.



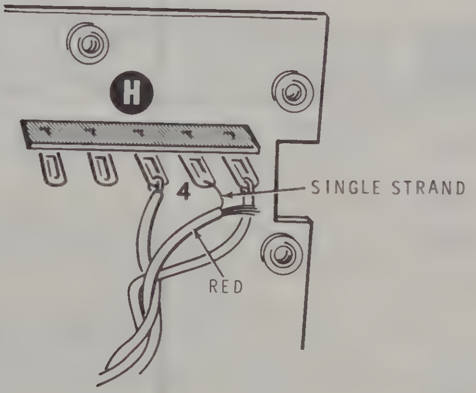
PICTORIAL 4-17



Detail 4-17A

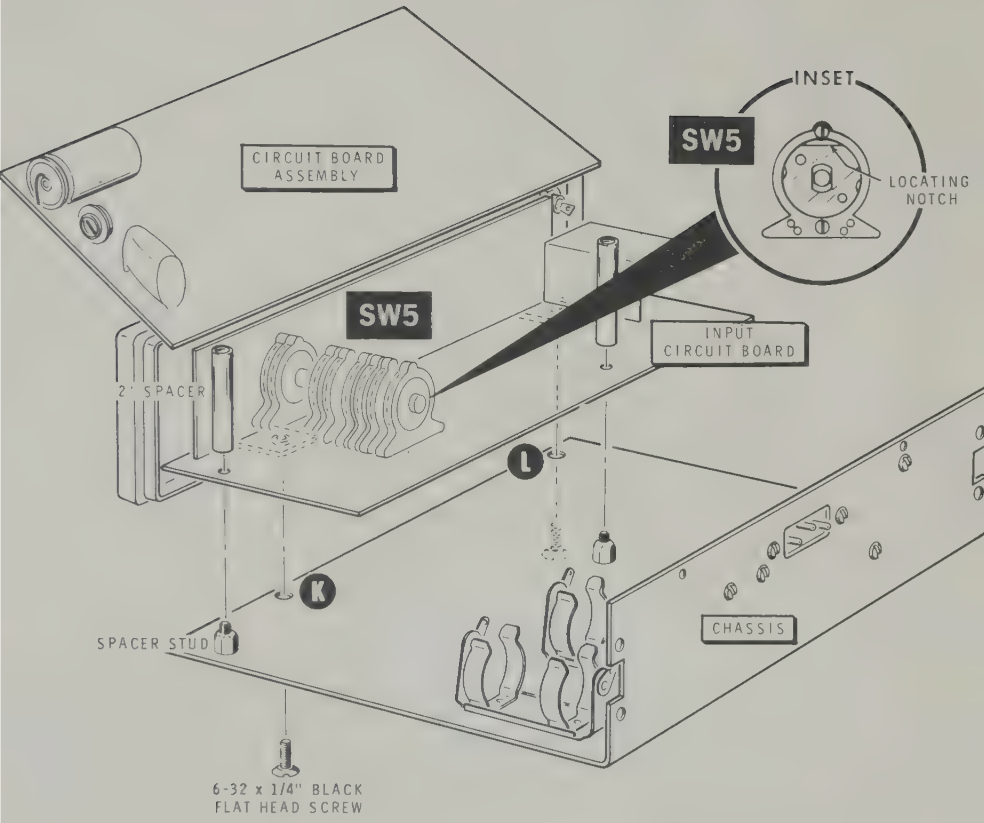
1. (●) Refer to Detail 4-17A and connect the ohmmeter common lead to the shield on the input circuit board. Then connect the other ohmmeter lead to the bare end of the red wire. If the resistance reading is 500 kΩ or greater, connect the red wire to terminal strip H, lug 4 (S-2). CAUTION: If the resistance reading is at or near zero, it indicates a short-circuit condition which could be caused by a solder bridge, wiring error, etc. Proceed to the "In Case of Difficulty" section on Page 91 and correct this condition before you connect the red wire.

2. ( ) Refer to Detail 4-17B and separate one of the strands at the end of the red wire and bend it over to one side. Then touch this single strand to lug 4 of terminal strip H and closely observe the wire strand. CAUTION: If you observe a spark, or if the strand discolors or glows, it indicates a short-circuit condition, which could be caused by a solder bridge, wiring error, etc. Proceed to the "In Case of Difficulty" section on Page 91 and correct this condition before you connect the red wire. If there are no indications of a short-circuit condition, connect the red wire to terminal strip H, lug 4 (S-2).

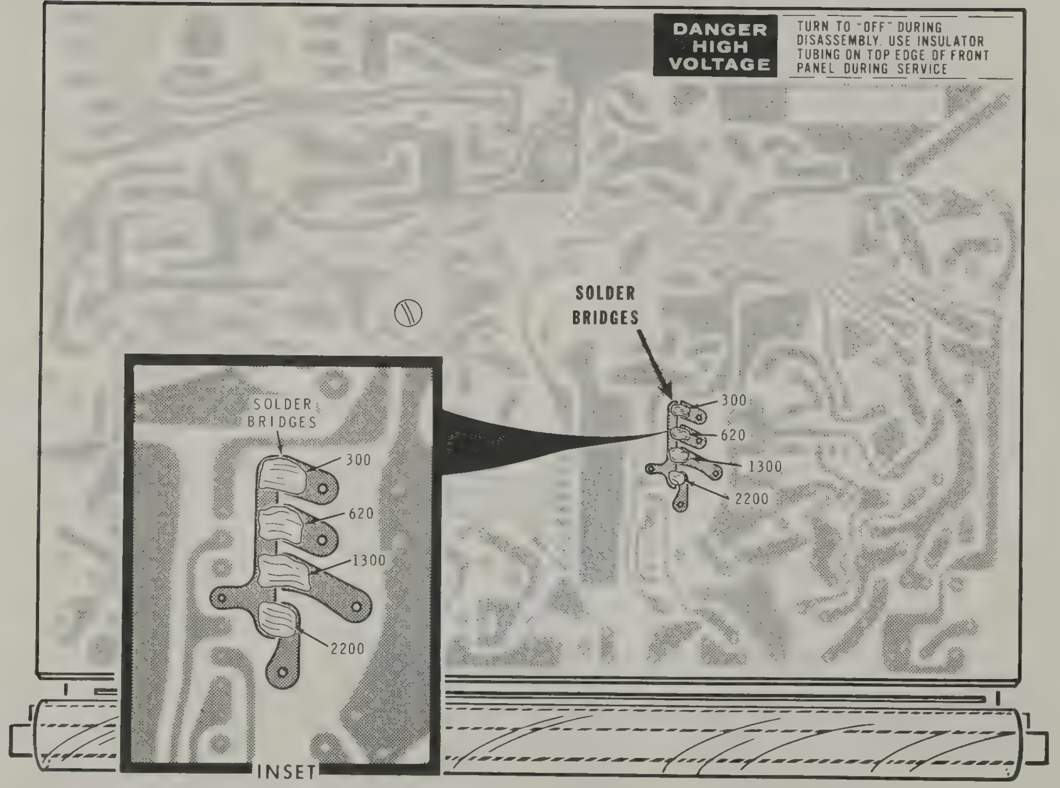


Detail 4-17B

0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



PICTORIAL 4-16


DANGER HIGH VOLTAGE
TURN TO "OFF" DURING DISASSEMBLY. USE INSULATOR TUBING ON TOP EDGE OF FRONT PANEL DURING SERVICE
SOLDER BRIDGES
300
620
1300
2200
SOLDER BRIDGES
300
620
1300
2200
INSET

Detail 4-18B

Refer to Pictorial 4-16 for the following steps.

( ) Position the chassis and the circuit board assembly as shown in the Pictorial and set the circuit board assembly down on the chassis so that the spacer studs go through the holes in the input circuit board.

( ) Fasten the circuit board assembly to the chassis with two 6-32 x 1/4" black flat head screws at K and L. Make sure the screws fit properly into the two mounting brackets before you tighten the screws.

( ) Locate the two 2" spacers and install them on the spacer studs as shown in the Pictorial.

( ) Refer to the inset drawing and rotate switch SW5 so that the locating notch on the rear of the switch is positioned as shown.

Refer to Pictorial 4-17 for the following steps.

( ) Refer to the Pictorial and to the battery installation label, and install the four batteries in the battery clips with the plus (+) marked end toward the front of the Multimeter.

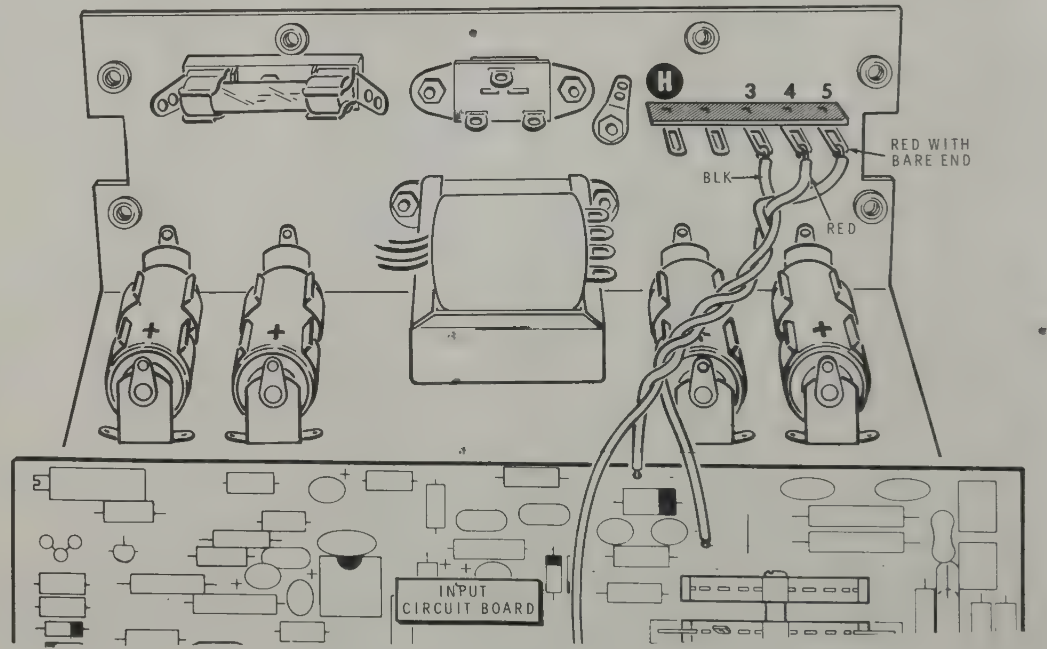
Position the assembled Multimeter as shown in the Pictorial and connect the twisted group of wires coming from the input circuit board to terminal strip H as follows:

( ) Black to lug 3 (S-4).

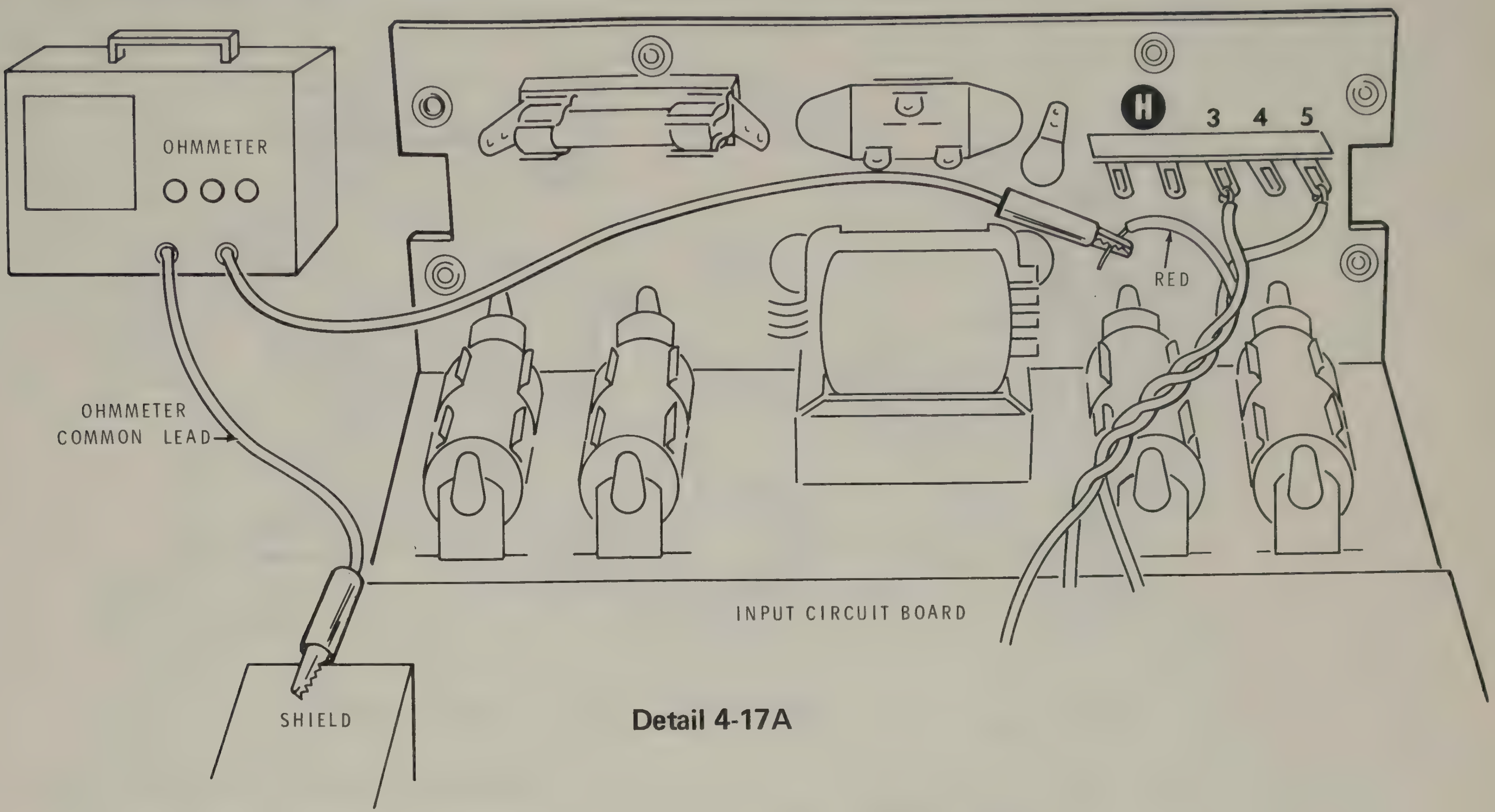
( ) Red (with bare end) to lug 5 (S-2).

( ) Remove 1/4" of insulation from the free end of the other red wire in the twisted group.

NOTE: Steps 1 and 2 on the next page describe two methods for making a short-circuit test before you connect the red wire. If an ohmmeter is available, perform only step 1. If an ohmmeter is not available, perform only step 2.



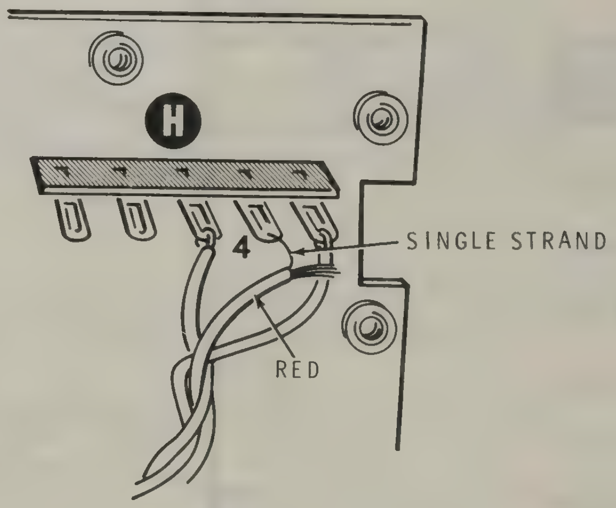
PICTORIAL 4-17



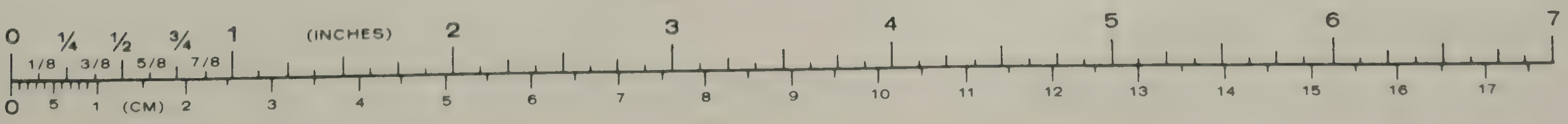
Detail 4-17A

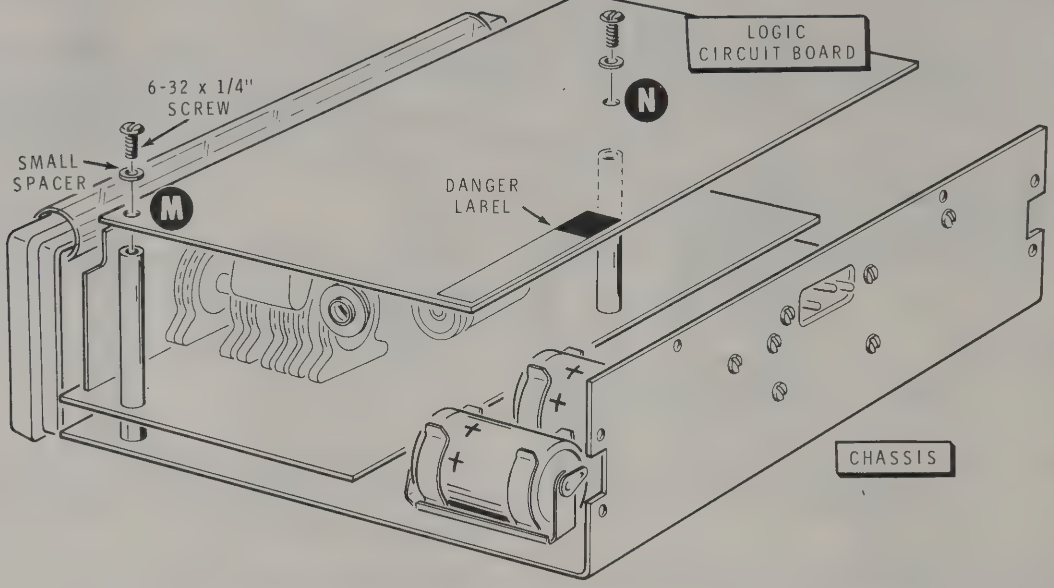
1. (●) Refer to Detail 4-17A and connect the ohmmeter common lead to the shield on the input circuit board. Then connect the other ohmmeter lead to the bare end of the red wire. If the resistance reading is 500 kΩ or greater, connect the red wire to terminal strip H, lug 4 (S-2). CAUTION: If the resistance reading is at or near zero, it indicates a short-circuit condition which could be caused by a solder bridge, wiring error, etc. Proceed to the "In Case of Difficulty" section on Page 91 and correct this condition before you connect the red wire.

2. ( ) Refer to Detail 4-17B and separate one of the strands at the end of the red wire and bend it over to one side. Then touch this single strand to lug 4 of terminal strip H and closely observe the wire strand. CAUTION: If you observe a spark, or if the strand discolors or glows, it indicates a short-circuit condition, which could be caused by a solder bridge, wiring error, etc. Proceed to the "In Case of Difficulty" section on Page 91 and correct this condition before you connect the red wire. If there are no indications of a short-circuit condition, connect the red wire to terminal strip H, lug 4 (S-2).

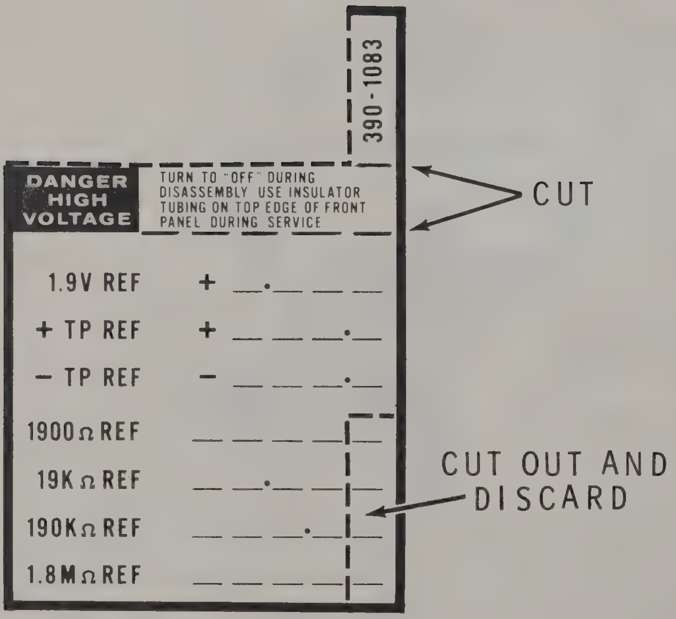


Detail 4-17B


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



PICTORIAL 4-18



Detail 4-18A

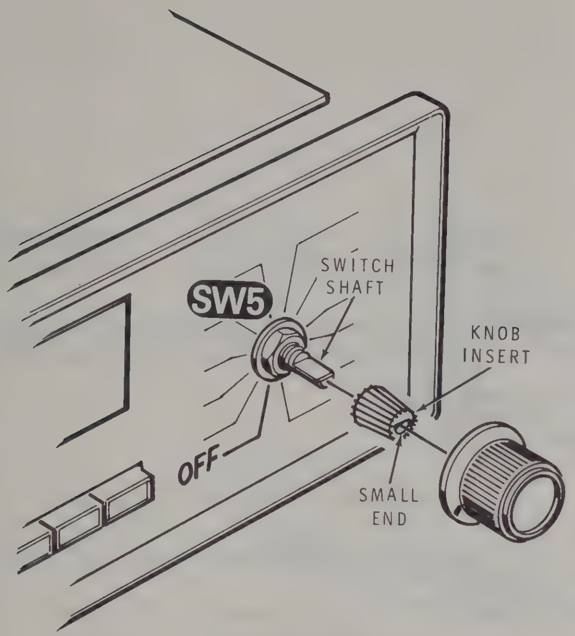
(●) Refer to Pictorial 4-18 and turn the logic circuit board over and fasten it to the chassis at M and N with two small spacers and two 6-32 x 1/4" screws. Make sure all wires under this circuit board are positioned so they will not be pinched before you tighten the screws.

(●) Refer to Detail 4-18A and cut the "DANGER HIGH VOLTAGE" label from the label card. Then peel off the protective backing and press the label into place on the logic circuit board as shown in the Pictorial.

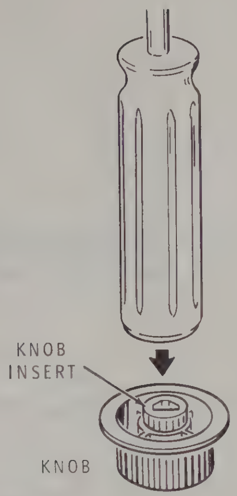
Refer to Detail 4-18B (fold-out from Page 68).

NOTE: In the following step, you will instructed to make solder bridges between foil patterns on the logic circuit board. These solder bridges will be used to calibrate your multimeter in later steps. To make the solder bridges, hold your soldering iron so that its tip touches both foils where the bridge is to be made. Then, melt a small amount of solder onto the tip and move the tip slowly back and forth from one foil to the other until the bridge is formed.

( ) Make four solder bridges at the areas marked "300" "620" "1300" and "2200." The inset drawing on the Detail shows a close-up view of the circuit board foil pattern.



PICTORIAL 4-19



Detail 4-19A

Refer to Pictorial 4-19 for the following steps.

(•) Position the multimeter as shown in the Pictorial. Do not change the position of SW5 during the following steps. NOTE: The flat on the switch shaft may be positioned toward the top as shown, or toward the bottom.

Notice that the knob insert is tapered. Be sure, in the next step, to place this insert on the shaft with the small end facing out, or the knob will not slide onto it. (Roll the insert on a flat surface if you are unsure about it; the insert will gradually turn toward the small end.)

(•) Install the knob insert on the switch shaft.

(•) Push the knob part way onto the insert with the white indicator pointing to the "OFF" position.

(•) Carefully remove the knob and insert together. Then press the insert fully into the knob with a tool as shown in Detail 4-19A.

(•) Replace the knob on the switch shaft.

~~( ) Locate the~~ two envelopes marked "100-1631 Calibration Voltage" and the calibration label (remaining label from the combination label card).

( ) Refer to Detail 4-18A and cut out the section from the calibration label as shown. Then discard the cut out section; it will not be used.

NOTE: In the following steps, when you transfer the calibration numbers from the envelopes to the label, record the numbers in ink (ball point pen etc.). The label will be installed inside the cabinet in later steps to serve as a permanent reference for calibrating your Multimeter.

THESE ENVELOPES & PARTS NOT FOUND 8/5/2006

From the envelope marked with a plus (+) sign:

( ) Transfer the number marked "HIGH" on the envelope, to the calibration label at the 1.9 V REF (1.9 volt reference).

( ) Transfer the number marked "LOW" to the label at the + TP REF (plus test point reference).

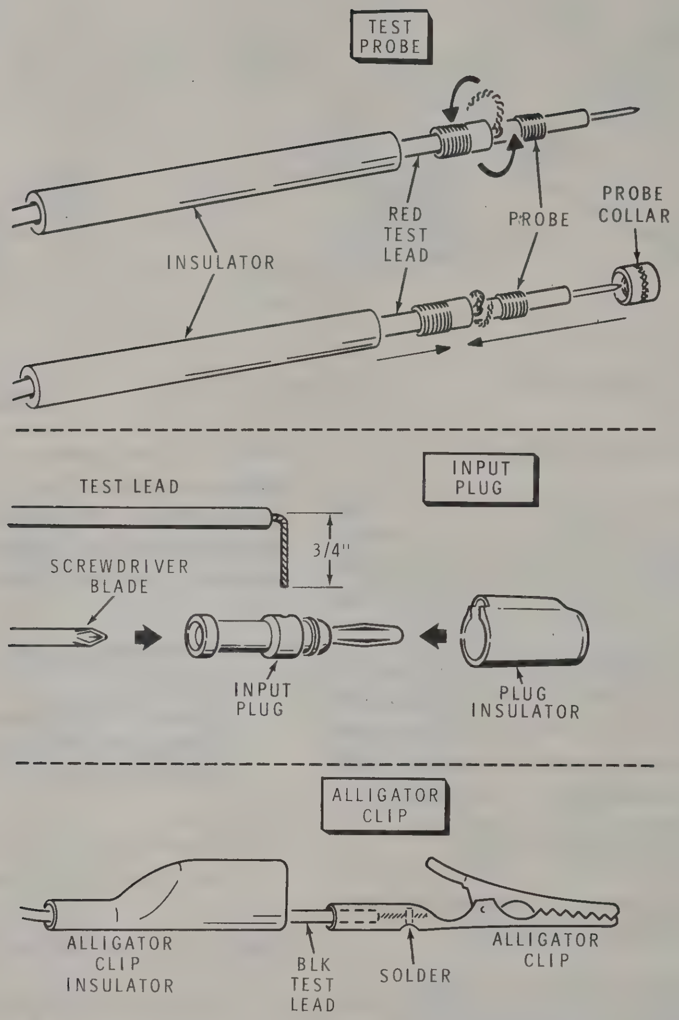
From the envelope marked with a minus (–) sign:

( ) Cross out the "HIGH" number; it will not be used.

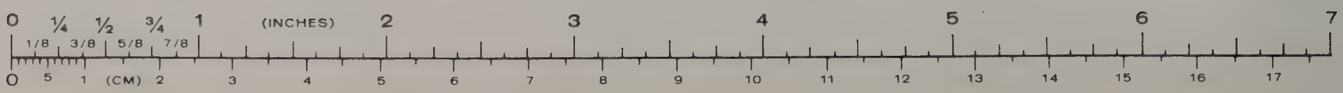
( ) Transfer the "LOW" number to the label at the – TP REF (minus test point reference).

( ) Locate the envelope marked, "100-1643 Standard Resistance Package," and transfer the numbers from the envelope to the corresponding spaces on the calibration label.

Proceed to "TEST LEAD AND CALIBRATION TOOL ASSEMBLY."



PICTORIAL 4-20


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

TEST LEAD AND CALIBRATION TOOL ASSEMBLY

Refer to Pictorial 4-20 for the following steps.

Locate the two 36" test leads you set aside earlier.

( ) Remove 1/2" of insulation from one end of the red test lead.

( ) Install a test probe on this end of the red test lead as follows:

1. Unscrew the insulator from the probe tip and insert the wire through the smaller hole in the insulator.
2. Twist the fine wires together and insert them through the hole in the probe. Then form the wires around the probe and screw the probe collar over them. Screw the insulator back on the probe.

( ) Remove 3/4" of insulation from the free end of the red test lead.

( ) Insert this end of the red test lead into an input plug as shown. Then bend the wire back flat against the plug body.

( ) Place the input plug on a small phillips screwdriver (or similar tool) and push a red plug insulator onto the plug and wire until the insulator snaps into place.

( ) Remove 3/4" insulation from one end of the black test lead.

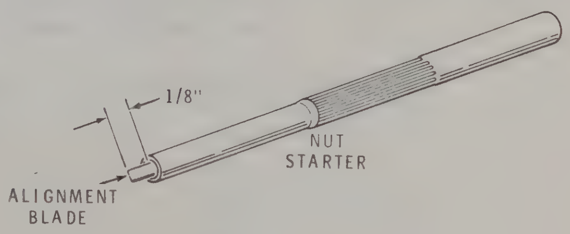
( ) Install an input plug and black plug insulator on this end of the black test lead.

( ) Remove 1/2" insulation from the free end of the black test lead.

( ) Insert the black test lead through the alligator clip insulator.

( ) Install an alligator clip on this end of the black test lead. Twist the fine wires together and insert them into the alligator clip (S-1).

( ) After the clip has cooled, slip the alligator clip insulator down over the alligator clip.



Detail 4-20A

( ) Refer to Detail 4-20A and with a pair of pliers push the 1" alignment blade into the smaller end of the nut starter until 1/8" remains exposed. Use this tool for the calibration adjustments.

This completes the assembly of your Digital Multimeter. The cabinet will be installed later. Proceed to the "Initial Tests" section of the Manual.

INITIAL TESTS

The purpose of this section of the Manual is to make sure your Meter will not be damaged as the result of a wiring error or other difficulty.

RESISTANCE CHECKS

To perform the following steps, you will need an ohmmeter that has a 1.5-volt test voltage. Most analog ohmmeters (VOM, VTVM) have this test voltage. If such an ohmmeter is not available, proceed to "Operational Check."

If the resistance in any of the following steps is less than called for, it will probably be near zero. This indicates a short circuit, possibly caused by a solder bridge. Correct this condition before you proceed. If you have any difficulty determining the cause of the problem, read the troubleshooting information on Pages 91 through 93. Then refer to the "Initial Tests Problems" chart on Page 93 to locate your problem.

( ) Refer to Figure 1 (fold-out from Page 77) and connect the ground, or common, ohmmeter lead to the shield.

( ) Switch the ohmmeter to the Rx100 range.

NOTE: If the readings are reversed when you perform the following step, reverse your ohmmeter test leads.

( ) Touch the ohmmeter input probe to point 1 on the logic circuit board. The reading should be near center scale. Momentarily reverse the ohmmeter test leads. The reading should be 4000 Ω or more. Then reverse the test leads again so they are connected as they were originally.

~ 4.5K Both WAYS

( ) Touch the ohmmeter probe to the following points on the logic circuit board foil. The readings should be greater than those shown.

POINT	READING GREATER THAN
2	400 Ω — 50K
3	5000 Ω — 17K
4	500 Ω — 2.7K
5	100 kΩ — 450K
6	1000 Ω — 5 MEG
7	∞ (infinite) — ∞

( ) Reverse the ohmmeter leads and again test:

POINT	READING GREATER THAN
2	100 kΩ — LOOKS LIKE VOLTAGE SOURCE
3	500 Ω — 8K
4	1000 Ω — 2.6K
5	1000 Ω — 300K
6	100 kΩ — ∞
7	∞ (infinite) — ∞

OPERATIONAL CHECK

( ) Depress the V/Ω and DC/Ω pushbuttons.

NOTE: It may take several seconds for all of the display digits to light.

( ) Rotate the RANGE switch to "BATT." The display should light with some number between "3.00" and "8.00." The other segments of the digits not brightly lit should be flashing dimly. If the display lights, proceed to "Calibration." If the display does not light, turn the RANGE switch to "OFF" and proceed to "LOW BATTERY CHECK."

LOW BATTERY CHECK

WARNING: Hazardous voltages are present at several places inside the Meter when the line cord is connected. In the following step, make sure you do not touch any bare wires, fuses, exposed foils, etc. The boxed-in areas in Figure 2 show the hazardous voltage areas.

( ) Turn the Range switch to OFF.

( ) Connect the line cord to the rear of the Meter and plug it into a standard AC outlet to charge the batteries. NOTE: Charge the batteries for at least one hour. Then turn the RANGE switch to "BATT." If the display then lights, proceed to "Calibration." If the display still does not light, disconnect the line cord and proceed to "In Case of Difficulty" on Page 91.

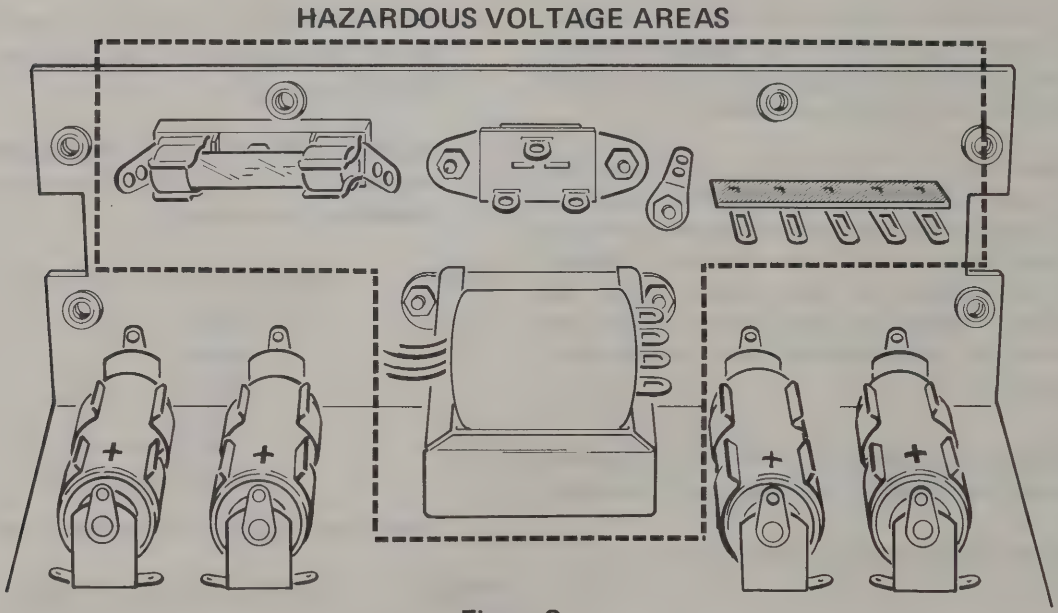


Figure 2

CALIBRATION

WARNING: Hazardous voltages are present at several places inside the Meter when the line cord is connected. In the following step, make sure you do not touch any bare wires, fuses, exposed foils, etc. The boxed-in areas in Figure 2 show the hazardous voltage areas.

( ) Rotate the RANGE switch to "OFF." Then connect the line cord to the rear of the Meter and plug it into a standard AC outlet to charge the batteries. Charge them for approximately 14 hours before you proceed with the calibration. NOTE: The batteries must be fully charged before the meter can be accurately calibrated.

( ) Disconnect the line cord before you proceed with the calibration.

If you do not get the indicated reading in a step, turn the RANGE switch to OFF and proceed to the "In Case of Difficulty" section on Page 91.

The following characteristics of the display, which occur during calibration, are normal:

1. Overrange is indicated by a flashing "1" in the left-end digit. (A "1" may also be lit in the right-end digit.)
2. The display may "count-up" on the 190 mVDC and 1.9 VDC ranges with the test leads open.
3. All ohmmeter ranges will show an overrange condition (flashing "1") with the test leads open.
4. When an AC voltage range is selected, the display reading may take a few seconds to settle.

NOTE: Two methods of calibration are provided in this section. The first ("Calibration With Built-in References") uses the internal, supplied references. The second (on Page 81) uses laboratory-grade standard references.

To perform the calibration with laboratory-grade standard references, you will need the following equipment:

1. A DC voltage standard that provides plus and minus 190 mVDC and 1.9 VDC with an accuracy greater than ±.04%.
2. A resistance standard that provides 1900 Ω, 19 kΩ, 190 kΩ, and 1.9 MΩ with an accuracy greater than ±.04%.
3. An AC voltage standard that provides 1.9 VAC RMS, 19.0 VAC RMS, 190 VAC RMS, and 750 VAC RMS with an accuracy greater than ±.1%. The output must be a low-distortion sine wave that covers a frequency range of 400 Hz to 8 kHz.

Choose one of the calibration methods and perform the steps for that method only.

OPERATIONAL CHECK

( ) Depress the V/Ω and DC/Ω pushbuttons.

NOTE: It may take several seconds for all of the display digits to light.

( ) Rotate the RANGE switch to "BATT." The display should light with some number between "3.00" and "8.00." The other segments of the digits not brightly lit should be flashing dimly. If the display lights, proceed to "Calibration." If the display does not light, turn the RANGE switch to "OFF" and proceed to "LOW BATTERY CHECK."

LOW BATTERY CHECK

WARNING: Hazardous voltages are present at several places inside the Meter when the line cord is connected. In the following step, make sure you do not touch any bare wires, fuses, exposed foils, etc. The boxed-in areas in Figure 2 show the hazardous voltage areas.

( ) Turn the Range switch to OFF.

( ) Connect the line cord to the rear of the Meter and plug it into a standard AC outlet to charge the batteries. NOTE: Charge the batteries for at least one hour. Then turn the RANGE switch to "BATT." If the display then lights, proceed to "Calibration." If the display still does not light, disconnect the line cord and proceed to "In Case of Difficulty" on Page 91.

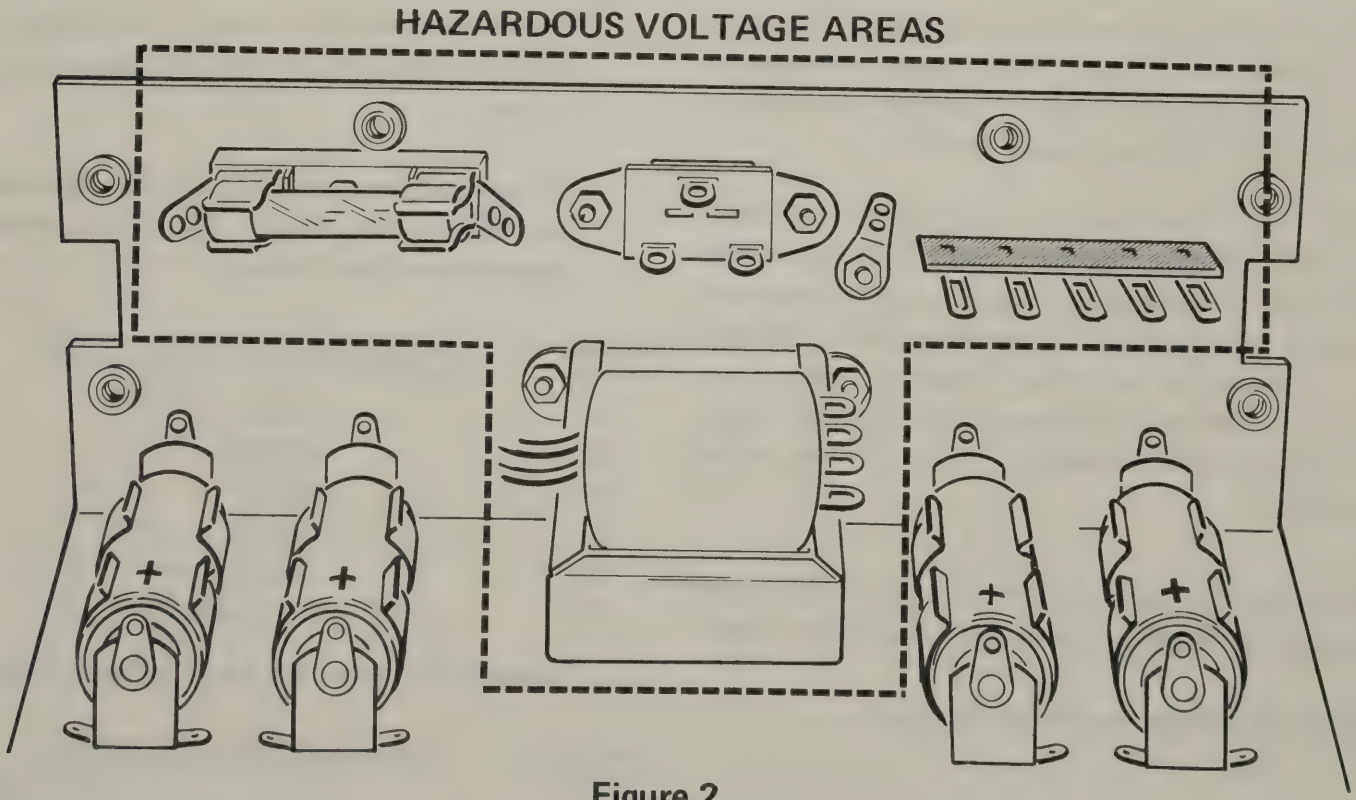


Figure 2

CALIBRATION

WARNING: Hazardous voltages are present at several places inside the Meter when the line cord is connected. In the following step, make sure you do not touch any bare wires, fuses, exposed foils, etc. The boxed-in areas in Figure 2 show the hazardous voltage areas.

( ) Rotate the RANGE switch to "OFF." Then connect the line cord to the rear of the Meter and plug it into a standard AC outlet to charge the batteries. Charge them for approximately 14 hours before you proceed with the calibration. NOTE: The batteries must be fully charged before the meter can be accurately calibrated.

( ) Disconnect the line cord before you proceed with the calibration.

If you do not get the indicated reading in a step, turn the RANGE switch to OFF and proceed to the "In Case of Difficulty" section on Page 91.

The following characteristics of the display, which occur during calibration, are normal:

1. Overrange is indicated by a flashing "1" in the left-end digit. (A "1" may also be lit in the right-end digit.)
2. The display may "count-up" on the 190 mVDC and 1.9 VDC ranges with the test leads open.
3. All ohmmeter ranges will show an overrange condition (flashing "1") with the test leads open.
4. When an AC voltage range is selected, the display reading may take a few seconds to settle.

NOTE: Two methods of calibration are provided in this section. The first ("Calibration With Built-in References") uses the internal, supplied references. The second (on Page 81) uses laboratory-grade standard references.

To perform the calibration with laboratory-grade standard references, you will need the following equipment:

1. A DC voltage standard that provides plus and minus 190 mVDC and 1.9 VDC with an accuracy greater than ±.04%.
2. A resistance standard that provides 1900 Ω, 19 kΩ, 190 kΩ, and 1.9 MΩ with an accuracy greater than ±.04%.
3. An AC voltage standard that provides 1.9 VAC RMS, 19.0 VAC RMS, 190 VAC RMS, and 750 VAC RMS with an accuracy greater than ±.1%. The output must be a low-distortion sine wave that covers a frequency range of 400 Hz to 8 kHz.

Choose one of the calibration methods and perform the steps for that method only.

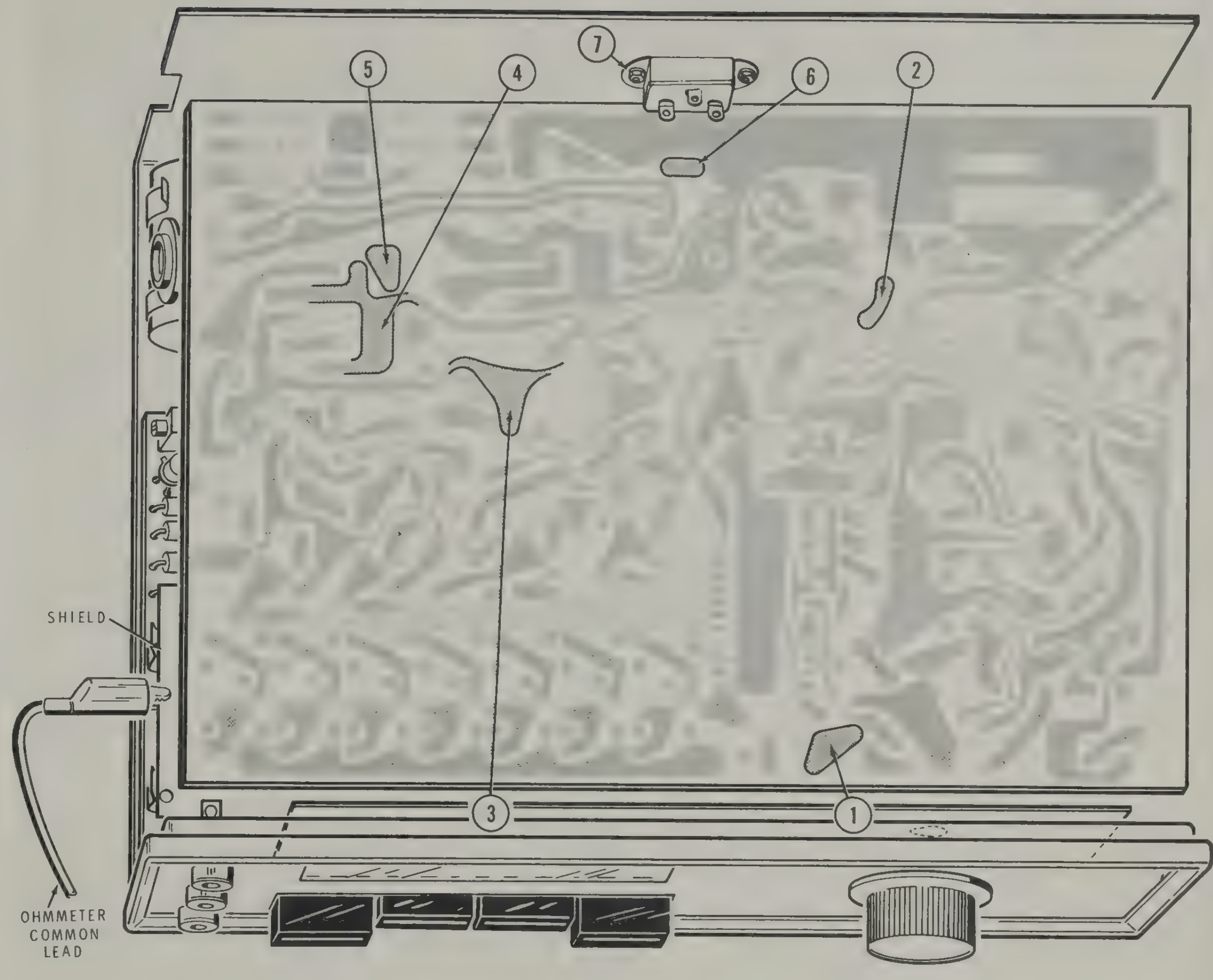
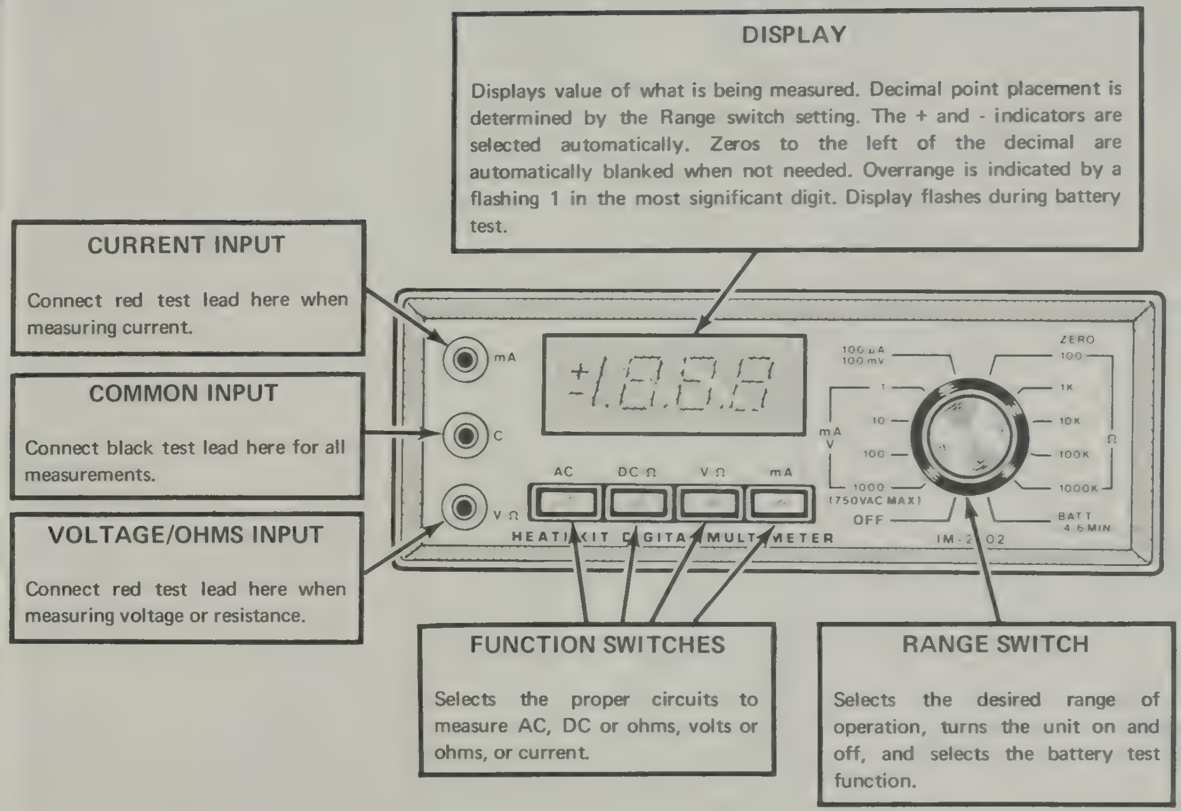


Figure 1



DISPLAY

Displays value of what is being measured. Decimal point placement is determined by the Range switch setting. The + and - indicators are selected automatically. Zeros to the left of the decimal are automatically blanked when not needed. Overrange is indicated by a flashing 1 in the most significant digit. Display flashes during battery test.

CURRENT INPUT

Connect red test lead here when measuring current.

COMMON INPUT

Connect black test lead here for all measurements.

VOLTAGE/OHMS INPUT

Connect red test lead here when measuring voltage or resistance.

FUNCTION SWITCHES

Selects the proper circuits to measure AC, DC or ohms, volts or ohms, or current.

RANGE SWITCH

Selects the desired range of operation, turns the unit on and off, and selects the battery test function.

Figure 3

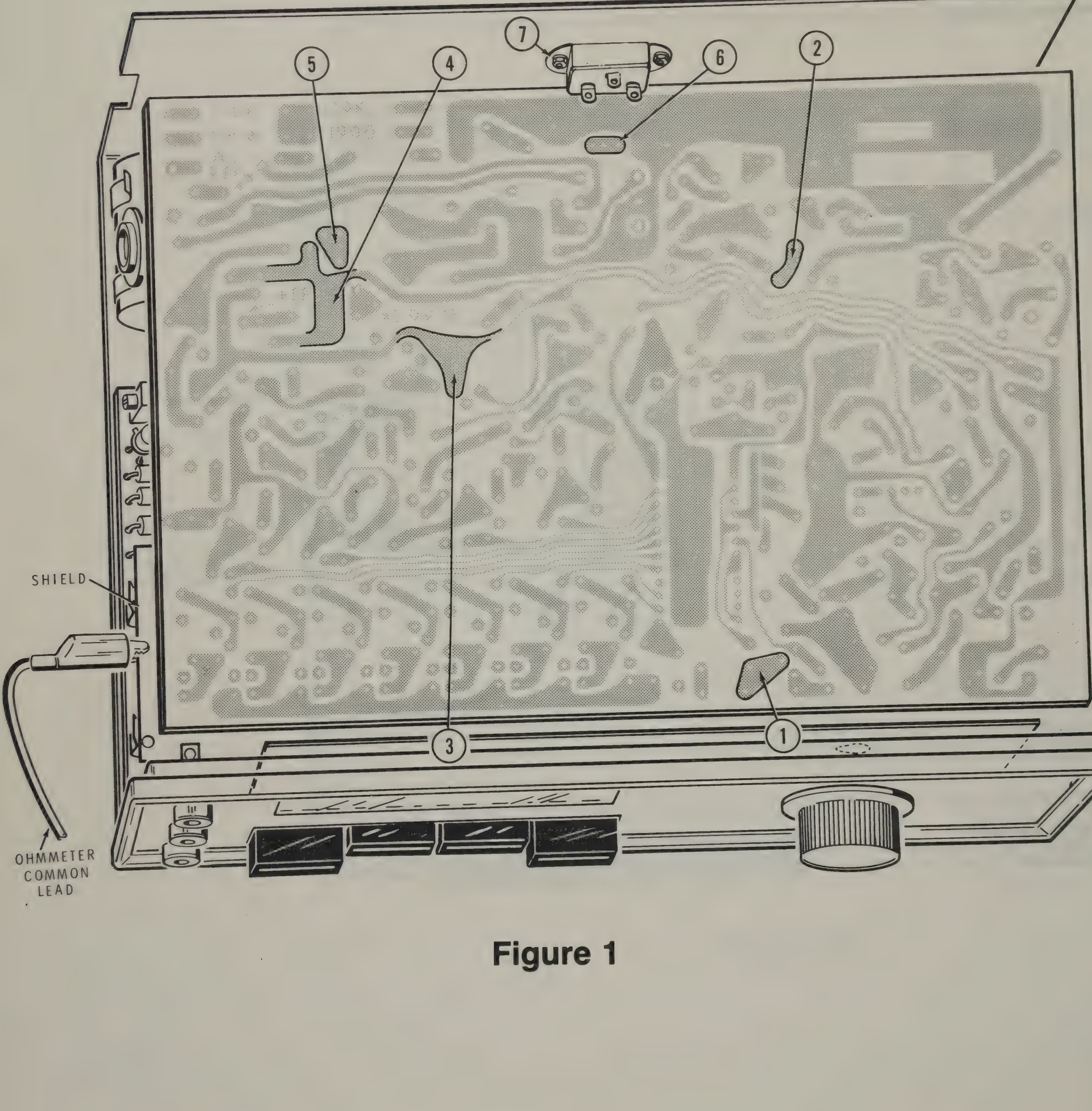


Figure 1

CAPACITANCE CHART

	REMOVE SOLDER BRIDGES			
SECONDS	300	620	1300	2200
20, 21, 22	X			
23, 24		X		
25, 26	X	X		
27, 28			X	
29, 30	X		X	
31, 32		X	X	
33, 34	X	X	X	
35 to 37	X			X
38 to 43		X		X
44 to 52	X	X		X
53 to 62			X	X
63 to 74	X		X	X
75+		X	X	X

Frequency Counter or Oscilloscope Method

(✓) Depress the DC/Ω and the V/Ω pushbuttons.

(✓) Rotate the RANGE switch to the 100 mA/V position. The display should be a .0 and the ± indicator should alternate between (+) and (−).

Refer to Figure 4 (fold-out from Page 78) for the following steps.

(✓) Connect the ground lead of the oscilloscope or frequency counter to the shield on the Multimeter.

(✓) Connect the signal lead from a high input impedance (10 kΩ or greater) oscilloscope or frequency counter input to the test point loop at FA. A DC pulse with a 3 to 5-volt positive peak should be present, with a period of 8 to 40 milliseconds or a frequency of 25 to 125 Hz.

NOTE: In the following numbered steps, you will be instructed to adjust the period of the DC pulse as close as possible to 8 milliseconds, which corresponds to a frequency of 125 Hz. To do this, you may have to remove one or more of the solder bridges that you made earlier on the logic circuit board foil. To remove a solder bridge, reheat the connection; then lift the soldering iron tip straight up. Always turn the RANGE switch to OFF before you make or remove any solder bridges.

1. (✓) Remove the 2200 solder bridge and observe the period or frequency. If the period becomes less than 7.4 milliseconds or the frequency is above 135 Hz, resolder the bridge. 142 HZ WHEN REMOVED

2. (✓) Remove the 1300 solder bridge and observe the period or frequency. If the period becomes less than 7.4 milliseconds or the frequency is above 135 Hz, resolder the bridge. 107 MS WHEN REMOVED

3. (✓) Observe the period or frequency that you now have and record it here: 107 ms.
   (300 and 620 both bridged)

4. (✓) Remove the 300 solder bridge. Then observe the period or frequency and record it here: 117 ms. (300 removed, 620 bridged)

5. (✓) Resolder the 300 solder bridge and remove the 620 solder bridge. Then observe the period or frequency and record it here 128 ms.
   (620 removed, 300 bridged)

NOTE: Perform step number 6 below, only if the 2200, or the 1300, or both solder bridges are connected at this time.

6. (✓) Remove both the 300 and the 620 solder bridge. Then observe the period or frequency and record it here ______.
   (300 and 620 both removed)

2210
4
300 CONNECT
FA

(✓) From steps 3 through 6 above, select the step which gives you a period closest to 8 milliseconds or a frequency closest to 125 Hz. Then solder or remove the bridges as directed in that step.

(✓) Disconnect the oscilloscope or frequency counter from the Multimeter.

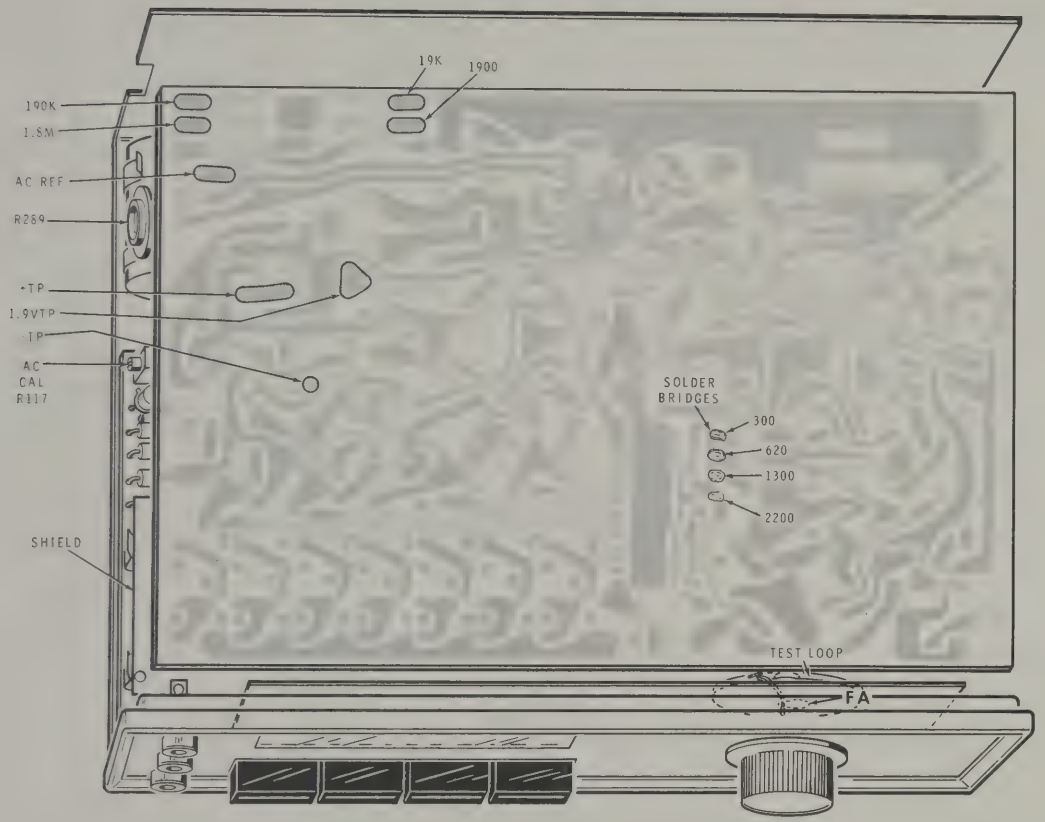


Figure 4

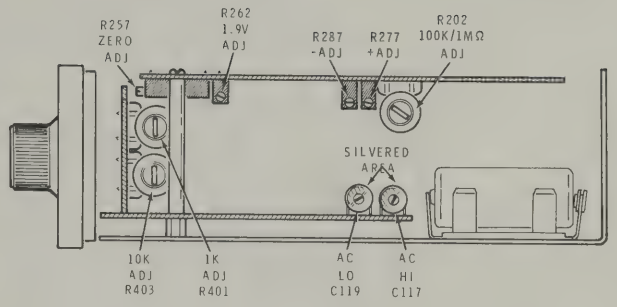


Figure 5

CALIBRATION WITH BUILT-IN REFERENCES

( ) Be sure the line cord is disconnected.

CAUTION: When you perform the following steps, make sure the test probe does not short the test point foils to any other foils on the circuit board.

ZERO ADJUSTMENT CHECK

Refer to Figure 3 (fold-out from Page 77) for the location and function of the controls.

( ) Plug the red test lead into the V/Ω jack.

( ) Plug the black test lead into the C jack.

( ) Clip the alligator clip to the test probe tip.

( ) Depress the DC/Ω and V/Ω pushbuttons.

( ) Rotate the RANGE switch to the 100 μA/mV position.

( ) Use a 1/8" blade screwdriver to rotate the ZERO – control (R257, through the hole in the upper right-hand corner of the front panel) until the display reads ±.0 so the + and – symbols light alternately.

( ) Remove the alligator clip from the test probe tip.

( ) Rotate the RANGE switch to OFF.

CLOCK FREQUENCY ADJUSTMENT

In the following steps, you will adjust the frequency of the internal clock as close as possible to 50 kHz. Two methods are described. The first method requires a stop watch or a watch with a second hand. The second method on Page 79 requires either a frequency counter or an oscilloscope with a calibrated horizontal sweep rate.

The frequency counter or oscilloscope method may produce better results. Perform only the method you choose.

WATCH METHOD

Refer to Figure 4 (fold-out from Page 78) for the following steps.

( ) Make sure all solder bridges are closed.

( ) Rotate the RANGE switch to the 100 kΩ position. The display should be a flashing 1. If not, rotate the RANGE switch to the 100 μA/mV position and hold the test probe tip on the 1.9 V TP (test point). The display should be a +1 and the 1 should flash.

NOTE: Hold the probe tip on the 1.9 V TP all during the next step.

( ) Count the time, in seconds, that it takes for the display to flash 100 times. An easy way to do this is by counting in groups of ten, keeping track on your fingers of the number of groups that occur. Repeat the procedure as many times as necessary to be sure of an accurate count within 1 second. Then, record the number of seconds here ____.

( ) If you counted 21 seconds or more in the previous step, some of the solder bridges, which you made earlier on the logic circuit board, must be removed. The "Capacitance Chart" below shows which solder bridges to remove, depending on the number of seconds you counted. Figure 4 (fold-out from this page) shows the location of the solder bridges.

( ) Turn the RANGE switch to OFF.

( ) Refer to the left-hand ("SECONDS") column of the capacitance chart and locate the number of seconds you counted. Then refer to the right-hand ("REMOVE SOLDER BRIDGES") column and remove the solder bridges indicated by an "X" for that number of seconds. For example: If you counted 31 seconds, you would remove solder bridges "620" and "1300." If you counted 55 seconds, you would remove solder bridges "1300" and "2200." To remove the bridges, reheat the connection, then lift the soldering iron tip straight up.

( ) Proceed to "DC Calibration" on Page 80.

CAPACITANCE CHART

	REMOVE SOLDER BRIDGES			
SECONDS	300	620	1300	2200
20, 21, 22	X			
23, 24		X		
25, 26	X	X		
27, 28			X	
29, 30	X		X	
31, 32		X	X	
33, 34	X	X	X	
35 to 37	X			X
38 to 43		X		X
44 to 52	X	X		X
53 to 62			X	X
63 to 74	X		X	X
75+		X	X	X

Frequency Counter or Oscilloscope Method

(✓) Depress the DC/Ω and the V/Ω pushbuttons.

(✓) Rotate the RANGE switch to the 100 mA/V position. The display should be a .0 and the ± indicator should alternate between (+) and (–).

Refer to Figure 4 (fold-out from Page 78) for the following steps.

(✓) Connect the ground lead of the oscilloscope or frequency counter to the shield on the Multimeter.

(✓) Connect the signal lead from a high input impedance (10 kΩ or greater) oscilloscope or frequency counter input to the test point loop at FA. A DC pulse with a 3 to 5-volt positive peak should be present, with a period of 8 to 40 milliseconds or a frequency of 25 to 125 Hz.

NOTE: In the following numbered steps, you will be instructed to adjust the period of the DC pulse as close as possible to 8 milliseconds, which corresponds to a frequency of 125 Hz. To do this, you may have to remove one or more of the solder bridges that you made earlier on the logic circuit board foil. To remove a solder bridge, reheat the connection; then lift the soldering iron tip straight up. Always turn the RANGE switch to OFF before you make or remove any solder bridges.

1. (✓) Remove the 2200 solder bridge and observe the period or frequency. If the period becomes less than 7.4 milliseconds or the frequency is above 135 Hz, resolder the bridge. 142 HZ WHEN REMOVED

2. (✓) Remove the 1300 solder bridge and observe the period or frequency. If the period becomes less than 7.4 milliseconds or the frequency is above 135 Hz, resolder the bridge. 107 MS WHEN REMOVED

3. (✓) Observe the period or frequency that you now have and record it here: 107 MS.
(300 and 620 both bridged)

4. (✓) Remove the 300 solder bridge. Then observe the period or frequency and record it here: 117 ms. (300 removed, 620 bridged)

5. (✓) Resolder the 300 solder bridge and remove the 620 solder bridge. Then observe the period or frequency and record it here 128 ms.
(620 removed, 300 bridged)

NOTE: Perform step number 6 below, only if the 2200, or the 1300, or both solder bridges are connected at this time.

6. (✓) Remove both the 300 and the 620 solder bridge. Then observe the period or frequency and record it here ________.
(300 and 620 both removed)

(✓) From steps 3 through 6 above, select the step which gives you a period closest to 8 milliseconds or a frequency closest to 125 Hz. Then solder or remove the bridges as directed in that step.

2210
4
300
CONNE

(✓) Disconnect the oscilloscope or frequency counter from the Multimeter.

DC CALIBRATION

Locate the calibration label; it will be used in the following steps.

( ) Rotate the RANGE switch to the 100 μA/mV position.

( ) Clip the alligator clip to the test probe tip and make sure the ZERO adjust is properly set for ±.0. (See Figure 5.) Then unclip the alligator clip from the test probe.

Refer to Figure 4 for the location of the test points in the following steps.

NOTE: When you perform the next two steps, the display count may vary slightly. If it does, adjust the range of the count variation equally above and below the number on the Calibration label.

( ) Touch the test probe tip to the + TP point on the foil side of the logic circuit board and adjust the + ADJ control (R277) so the meter displays the + TP REF number on the calibration label.

( ) Touch the test probe tip to the – TP point and adjust the – ADJ control (R287) so the Meter displays the – TP REF number on the calibration label.

( ) Rotate the RANGE switch to the 1 mA/V position.

( ) Touch the test probe tip to the 1.9 V TP and adjust the 1.9 V ADJ control (R262) so the meter displays the 1.9 V REF number on the calibration label.

( ) Repeat the above steps for "DC CALIBRATION" to eliminate any small changes that may have occurred.

RESISTANCE CALIBRATION

( ) Rotate the RANGE switch to the 100 KΩ position. The display should be a flashing "1".

( ) Touch the test probe tip to the 190 KΩ test point (see Figure 4 on fold-out from Page 78) and adjust the 100K/1M ADJ control (R202, see Figure 5) so the meter displays the 190 KΩ REF number on the calibration label.

( ) Rotate the RANGE switch to the 1000 KΩ position.

( ) Touch the test probe tip to the 1.8M test point and allow time for the display to stabilize (about 20 seconds). Note the difference between the reading and the 1.8M REF number on the calibration label. Then adjust the 100K/1M ADJ so the reading is midway between these two numbers.

NOTE: The above procedure should equally divide any calibration error between the 100K and the 1,000K ranges.

( ) Rotate the RANGE switch to the 10 KΩ position.

( ) Touch the test probe tip to the 19K test point and adjust the 10K ADJ control (R403) to display the 19K REF number on the calibration label.

( ) Rotate the RANGE switch to the 1 KΩ position.

( ) Touch the test probe tip to the 1900 test point and adjust the 1K ADJ (R401) control to display the 1900 REF number on the calibration label.

AC CALIBRATION

NOTE: Do not depress the AC pushbutton until instructed to do so.

( ) Position the silvered half of the AC HI (C117) and AC LO (C119) trimmer capacitors as shown in Figure 5 (fold-out from Page 78).

WARNING: Exposed line voltage is present on the chassis during the next steps.

( ) Connect the line cord to the Multimeter and plug it into a standard AC outlet.

( ) Rotate the RANGE switch to the 1 mA/V position.

( ) Touch the test probe tip to the AC REF test point (see Figure 4) and adjust the AC REF control (R289) for a reading that varies around –1.225. The variation that occurs in the last few digits is caused by an AC-type voltage being measured on a DC range.

( ) Without removing the test probe or changing the AC REF adjustment, depress the AC pushbutton.

( ) Adjust the AC CAL control (R117) for a reading of 1.507.

( ) Rotate the RANGE switch to OFF.

( ) Disconnect the line cord.

( ) Disconnect the red and black test leads.

This completes the Calibration of your Multimeter. However, after it has been in use for some time – three months for example – you may wish to touch up the calibration to remove any small "burn-in" drift.

Proceed to "Final Assembly" on Page 85.

CALIBRATION WITH LABORATORY STANDARD REFERENCES

Make sure the accuracy of your calibration standards is at least 5 times more accurate than the Laboratory Standards Accuracy Specification on Page 113. For example, to obtain an accuracy of ±0.2%, the Laboratory Standard must be accurate to within ±0.04%.

NOTE: Make sure the batteries in your Multimeter are fully charged before you begin the calibration.

ZERO ADJUSTMENT CHECK

( ) Connect the red test lead to the V/Ω jack.

( ) Connect the black test lead to the C jack.

( ) Clip the alligator clip to the test probe tip.

( ) Depress the DC/Ω and V/Ω pushbuttons.

( ) Rotate the RANGE switch to the 100 μA/mV position.

( ) Use a 1/8" blade screwdriver to rotate the ZERO control (R257, through the hole in the upper right-hand corner of the front panel) until the display reads–8.0. Rotate the control in the opposite direction until the display reads +8.0. Then rotate the control until the display again reads ±.0, so that the + and – symbols light alternately.

( ) Rotate the RANGE switch to OFF.

CLOCK FREQUENCY ADJUSTMENT

( ) Depress the DC/Ω and the VΩ pushbuttons.

( ) Rotate the RANGE switch to the 100 mA/V position. The display should be a .0 and the ± indicator should alternate between (+) and (–).

Refer to Figure 4 (fold-out from Page 78) for the following steps.

( ) Connect the ground lead of the oscilloscope or frequency counter to the shield on the Multimeter.

( ) Connect the signal lead from a high input impedance (10 kΩ or greater) oscilloscope or frequency counter input to the test point loop at FA. A DC pulse with a 3 to 5-volt positive peak should be present, with a period of 8 to 40 milliseconds or a frequency of 25 to 125 Hz.

NOTE: In the following numbered steps, you will adjust the period of the DC pulse as close as possible to 8 milliseconds, which corresponds to a frequency of 125 Hz. To do this, you may have to remove one or more of the solder bridges that you made earlier on the logic circuit board foil. To remove a solder bridge, reheat the connection, then lift the soldering iron tip straight up.

1. ( ) Remove the 2200 solder bridge and observe the period or frequency. If the period becomes less than 7.4 milliseconds, or the frequency is above 135 Hz, resolder the bridge.

2. ( ) Remove the 1300 solder bridge and observe the period or frequency. If the period becomes less than 7.4 milliseconds, or the frequency is above 135 Hz, resolder the bridge.

3. ( ) Observe the period or frequency that you now have and record it here: ____________________.
   (300 and 620 both bridged)

4. ( ) Remove the 300 solder bridge. Then observe the frequency or period and record it here: ____________________ (300 removed, 620 bridged)

5. ( ) Resolder the 300 solder bridge and remove the 620 solder bridge. Then observe the period or frequency and record it here: ____________________ (620 removed, 300 bridged).

NOTE: Perform step number 6 below, only if the 2200, the 1300, or both solder bridges are connected at this time.

6. ( ) Remove both the 300 and the 620 solder bridges. Then observe the period or frequency and record it here: ____________________
   (300 and 620 both removed)

( ) From steps 3 through 6 above, select the step which gives you a period closest to 8 milliseconds or a frequency closest to 125 Hz. Then, solder or remove the bridges as directed, in that step.

( ) Disconnect the frequency counter or oscilloscope from the Multimeter.

DC CALIBRATION

( ) Rotate the RANGE switch to the 100 μA/mV position.

( ) Clip the alligator clip to the test probe tip and make sure the ZERO adjust is properly set for ±.0. Then unclip the alligator clip from the test probe.

( ) Connect the meter test leads to a +190.0 millivolts supply. Refer to Figure 5 and adjust the + ADJ control (R277) until the display reads +190.0. Periodic changes to +189.9 or +190.1 are acceptable as long as +190.0 shows most of the time.

( ) Change the supply voltage to -190.0 millivolts. Adjust the – ADJ control (R287) until the display reads -190.0.

( ) Change the supply voltage to +1.900 volts (1900 millivolts). The display should be +1__ . __with a flashing 1.

( ) Rotate the RANGE switch to the 1 mA/V position.

( ) Adjust the 1.9 V ADJ control (R262) until the display reads +1.900.

( ) Repeat all the above steps to eliminate any small changes that may have occurred.

RESISTANCE CALIBRATION

( ) Rotate the RANGE switch to the 100 KΩ position.

( ) Connect a resistance of 190 kΩ to the meter test leads.

( ) Refer to Figure 5 and adjust the 100K/1M ADJ control (R202) until the display reads 190.0.

( ) Rotate the RANGE switch to the 1000 KΩ position.

( ) Connect a resistance of 1.9 MΩ to the meter test leads. Allow time for the display to completely settle (about 20 seconds). Note any error in the reading.

( ) Adjust the 100K/1M ADJ control (R202) so the reading is midway between the last reading and 1.9 M.

( ) Rotate the RANGE switch to the 10 KΩ position.

( ) Connect a resistance of 19 kΩ to the meter test leads.

( ) Adjust the 10 K ADJ control (R403) until the display reads 19.00.

( ) Rotate the RANGE switch to the 1 KΩ position. The display should be 1__ . __with a flashing 1.

( ) Connect a resistance of 1900 Ω to the meter test leads.

( ) Adjust the 1 K ADJ control (R401) until the display reads 1900.

( ) Disconnect the meter test leads.

AC CALIBRATION

( ) Refer to Figure 5 (fold-out from Page 78) and position the silver half of the AC HI and AC LO trimmer capacitors as shown.

( ) Depress the AC and V/Ω pushbuttons.

( ) Rotate the RANGE switch to the 1.0 mA/V position.

( ) Connect the meter test leads to a 1.9 volt RMS AC, 400 Hz supply.

( ) Adjust the AC CAL control (R117) until the display reads 1.900.

WARNING: High voltage will be used in the following steps. Be careful.

1. ( ) Rotate the RANGE switch to the 1000 mA/V position.
2. ( ) Change the voltage supply to 750.0 VAC at 2000 Hz.
3. ( ) Using an INSULATED, low capacity, tuning tool, adjust the AC HI trimmer capacitor (C117) until the display reads "748."

NOTE: If you are unable to adjust the display for a reading of "748," complete steps A through E below.

A. ( ) Turn the AC voltage supply off.

B. ( ) Turn the Multimeter off.

C. ( ) Turn the Multimeter over and remove the four flat head screws.

D. ( ) Refer to Figure 6 and remove the 4.7 pF capacitor at C115 on the input circuit board. Then, install the 6.8 pF capacitor taped at the top of this page at C115, solder the leads to the foil, and cut off the excess lead lengths.

E. ( ) Reassemble the Multimeter and return to step 1.

4. ( ) Change the voltage supply to 190.0 VAC.

5. ( ) Rotate the RANGE switch to the 100 mA/V position.

6. ( ) Change the voltage supply frequency to 8 kHz.

7. ( ) Adjust the AC LO trimmer capacitor (C119) until the display reads "190.4."

8. ( ) Change the voltage supply to 19.00 VAC.

9. ( ) Rotate the Multimeter range switch to the 10 mA/V position.

10. ( ) Observe the number on the display and record the number here______________________________.

11. ( ) Adjust the AC LO trimmer (C119) so the display reads halfway between the number recorded above and "19.04."

( ) Repeat steps 1 through 11.

( ) Turn the AC voltage supply to zero and disconnect it.

( ) Rotate the RANGE switch to OFF.

This completes the calibration of your Multimeter. However, after it has been in use for some time — three months for example — you may wish to touch up the calibration to remove any "burn-in" drift.

Proceed to "FINAL ASSEMBLY" on Page 85.

INPUT CIRCUIT BOARD

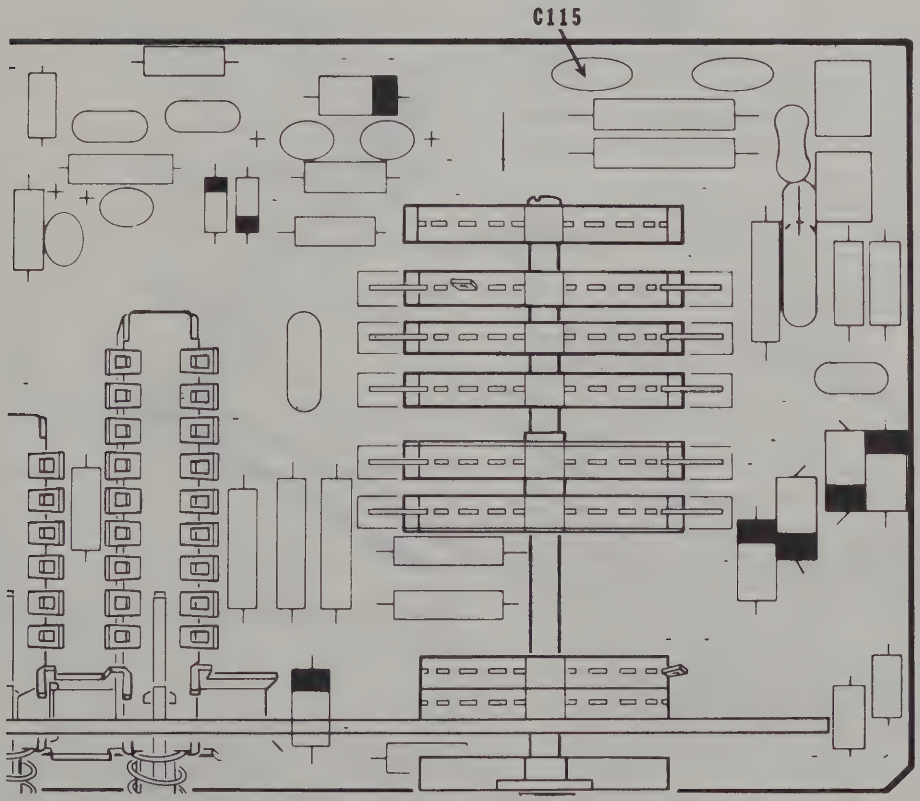
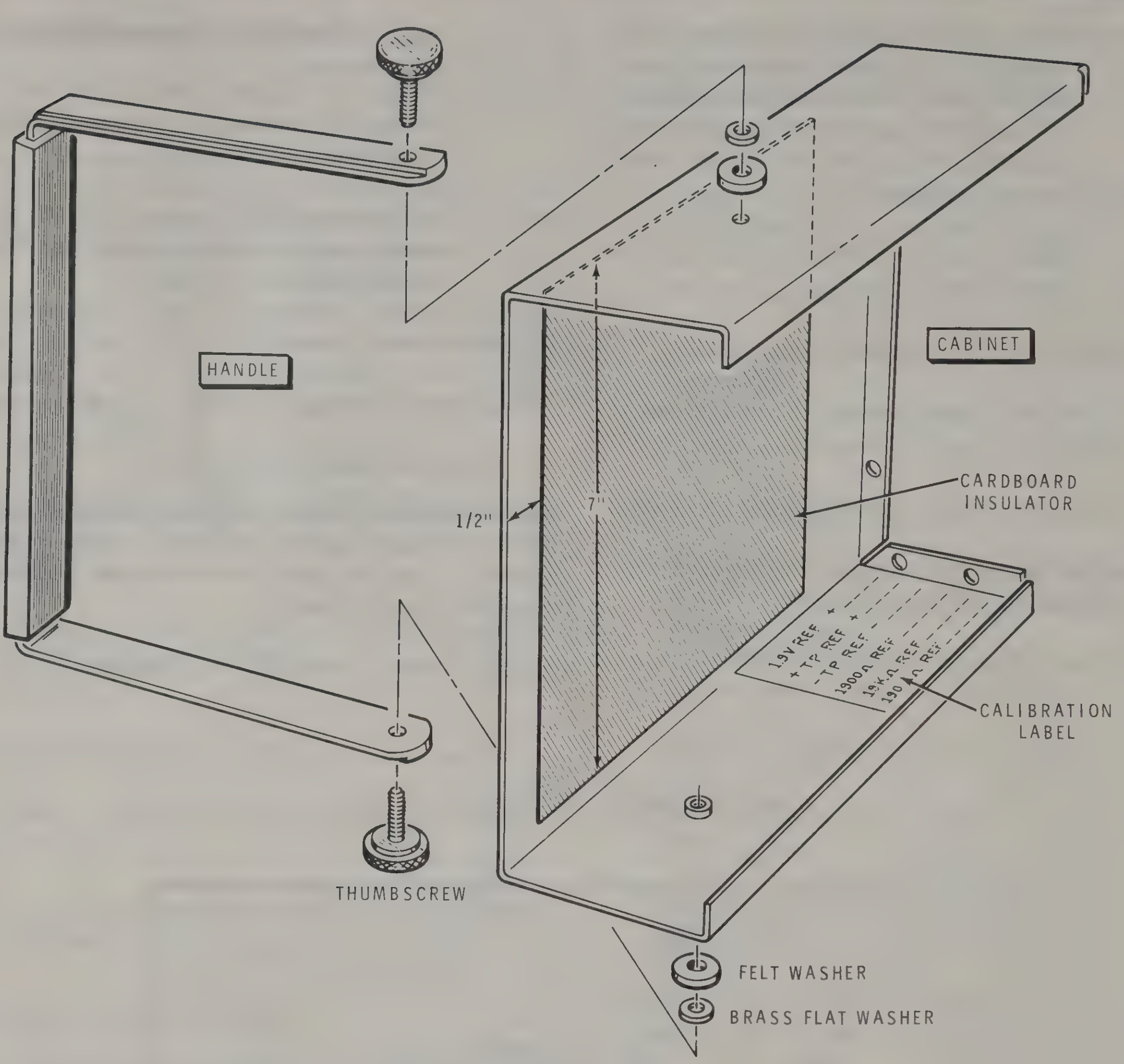
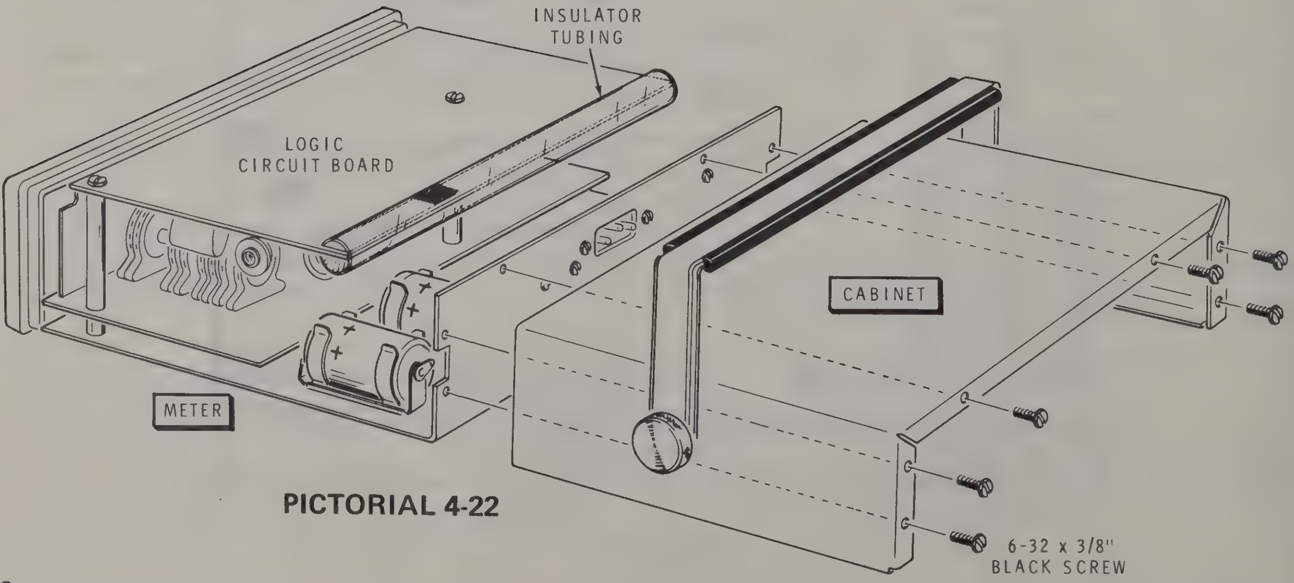


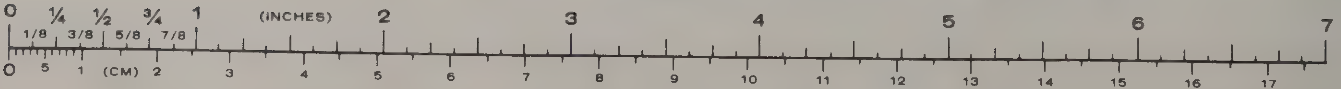
Figure 6



PICTORIAL 4-21



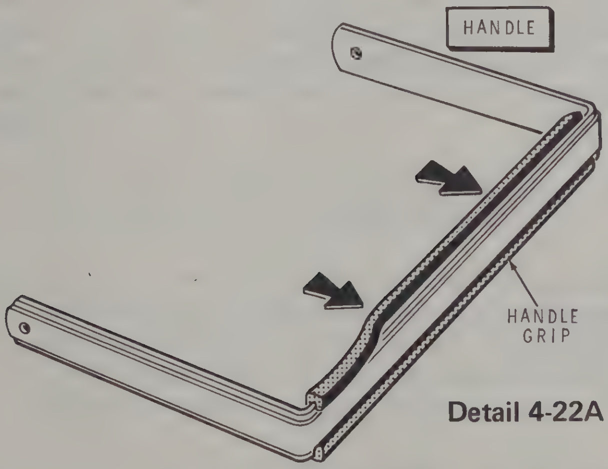
PICTORIAL 4-22



FINAL ASSEMBLY

( ) Position the cabinet on its side as shown in Pictorial 4-21. Then peel the backing paper from the calibration label and press the label into place on the inside of the cabinet as shown.

( ) Locate the cardboard insulator and cut it to a length of 7" as shown. Then peel off the backing paper and press the insulator into place on the cabinet 1/2" from the front edge.



Detail 4-22A

Refer to Pictorial 4-22 for the following steps.

( ) Refer to Detail 4-22A and install the handle grip on the handle as shown.

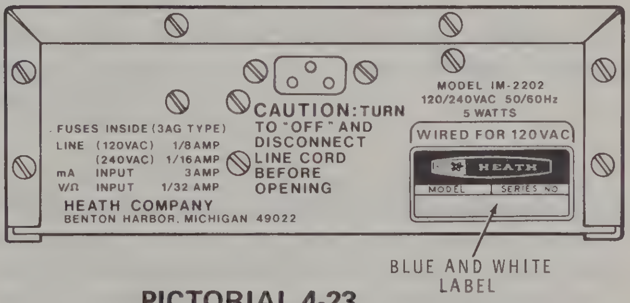
( ) Install the handle on the cabinet with two felt washers, two brass flat washer, and the two thumbscrews as shown in the Pictorial. Screw the thumbscrews in two or three turns, just enough to hold the handle in place.

( ) Position the Meter as shown in the Pictorial and place the length of insulator tubing on the rear edge of the logic circuit board. This is a convenient place to store the insulator tubing and it will always be handy when you need it.

CAUTION: Make sure the line cord is disconnected and the Range switch is turned off.

( ) Install the Meter into the cabinet with six 6-32 x 3/8" black screws.

NOTE: You can tighten the thumbscrews with the handle in any position. This allows you to carry the Multimeter by the handle, place the handle out of the way for storage, or you can use the handle under the Multimeter as a tilt-stand.



PICTORIAL 4-23

( ) Remove the backing paper from the blue and white identification label. Then refer to Pictorial 4-23 and press the label into place on the rear of the Multimeter so the correct wiring information is exposed and the incorrect information is covered up. NOTE: This blue and white identification label shows the model and series numbers of your kit. Always refer to these numbers in any communications with the Heath Company about your kit.

Proceed to "Operation."

OPERATION

Refer to Figure 3 (fold-out from Page 77) for a brief description of each control function.

NOTE: Always turn the RANGE switch to the OFF position when the Meter is not being used so the batteries do not become discharged.

SAFETY PRECAUTIONS

You may often use your Meter to check, maintain, and repair electronic equipment which contains DANGEROUSLY HIGH VOLTAGES. Because of this danger, you should always observe the safety procedures listed below.

1. Always handle the test probe by the insulated portion only. Be careful not to touch the exposed tip.
2. When you measure high voltages, turn off the power to the equipment to be tested before you connect the test leads. If this is not possible, be very careful to avoid accidental contact with any object that could provide a ground return (circuit completion) path.
3. If at all possible, use only one hand when you make tests on equipment that is turned on. Keep one hand in your pocket or behind your back to help avoid accidental shock.
4. If possible, insulate yourself from ground while you make measurements. Stand on a properly insulated floor or floor covering.
5. Before you connect the test leads for a resistance measurement, turn off the power to the equipment to be tested, and discharge any capacitors which may have stored a charge.

INPUT OVERLOAD PROTECTION

All circuits are protected against overloads, either through resistor-diode networks or fuses.

CONNECTING THE MULTIMETER

Turn the RANGE switch to OFF.

Plug the line cord into the rear panel AC socket and connect it to an AC outlet.

Plug the black test lead into the C jack and the red lead into the appropriate other jack.

Use the instructions on the following pages according to the type of measurement to be made (voltage, current, resistance, etc.)

When the Multimeter is turned on, the display should show digits (usually zeros) to the right of the decimal point, or just a 0 in the right-hand digit if there is no decimal point (such as in the 1000 mA/V position). In DC/Ω, the + and – should alternate and the display should read 0 with the leads shorted together. When it is operating on the two lowest DC voltage ranges and the test leads are not connected, it is normal for a constantly increasing number to be displayed until the unit reaches overrange, or until the leads are connected together.

NOTE: When the Multimeter is in the lowest resistance range, the resistance of the meter leads alone may cause the display to be .1 or .2.

±1 COUNT

It is normal for the right-hand digit of the display to alternate one number above and below a reading on successive counts.

USE WITH ACCESSORY PROBES

High Voltage Probe

This Multimeter can normally be used with a high voltage probe on DC only. The probe must be designed for a meter having a 10 MΩ input impedance, such as on the 10-, 100-, and 1000-volt positions on this Multimeter. (A high voltage probe of this type is available from the Heath Company.) The Multimeter should be set for a range determined by the voltage division ratio of the probe. If, for example, you are using a 100:1 probe and you expect to measure approximately 14,000 VDC, then the Multimeter should be set on its 100 VDC range and the display reading must be multiplied by 100. If you do not know what the approximate voltage reading will be, set the Multimeter on the 1000 VDC range. You can reduce the range setting later, if necessary.

CAUTION: Make sure you do not exceed the voltage rating of the probe.

RF PROBE

An RF probe can be used with the Multimeter. It should be connected to the V/Ω input jack. Depress the DC/Ω and V/Ω pushbuttons and initially set the Range switch in the 100 mA/V position.

CAUTION: Do not exceed the rated input voltage of the probe.

DC VOLTAGE MEASUREMENTS

1. Depress the DC/Ω and V/Ω pushbuttons.
2. Set the Range switch to the 1000 mA/V position, or to the desired lower range.
3. Apply the input to the V/Ω and C jacks and observe the readings. Lower the setting of the Range switch until you reach the proper range. If the display flashes an overrange condition, switch to a higher range. The following table indicates the readout limits for each range.

RANGE	READOUT LIMIT
100 mV	.0 - 199.9
1 V	.000 - 1.999
10 V	.00 - 19.99
100 V	.0 - 199.9
1000 V	0 - 1000 MAXIMUM

CAUTION: Never connect the common meter lead to any point that exceeds 1500 volts above power line ground (earth ground) during line operation. To do so may damage your Multimeter.

AC VOLTAGE MEASUREMENTS

NOTE: The AC converter in your Multimeter is an average-sensing circuit. Therefore, if you measure any AC voltage that is other than a pure sine wave; there will be an error in the reading. Square waves, sawtooth waves, etc. can be measured best with an oscilloscope.

1. Depress the AC and V/Ω pushbuttons.
2. Set the RANGE switch to 750 or the desired lower range.

CAUTION: Do not measure more than 750 volts AC.

3. Apply the voltage input to the V/Ω and C jacks and observe the reading. Lower the setting of the RANGE switch until you reach the proper range. If the display flashes an overrange condition, switch to a higher range, as an overload exists. It may take several seconds after you apply an input until the display reading stabilizes. The following table indicates the readout limits for each range.

RANGE	READOUT LIMIT
100 mV	0 - 199.9
1.0 V	.000 - 1.999
10 V	.00 - 19.99
100 V	.0 - 199.9
750 VAC	0 - 750 MAXIMUM

NOTE: When you measure AC voltages in high impedance circuits on the 100 mV and 1.0 V ranges, some display variation may be present due to stray line-voltage radiation.

DC CURRENT MEASUREMENTS

1. Depress the DC/Ω and mA pushbuttons.

2. Set the RANGE switch to 1000 or the desired lower range if known.

CAUTION: Do not exceed three amperes of DC current on the 1000 mA range. If this is exceeded, a fuse will open, the display will read zero, and the circuit under test will be opened.

3. Plug the meter test leads into the mA and C jacks. Then connect them to the circuit to be tested and observe the reading. Lower the setting of the RANGE switch until you reach the proper range. If the display flashes an overrange condition, switch to a higher range immediately, as an overload condition exists. The following table indicates the readout limits for each range.

RANGE	READOUT LIMIT
100 μA	0 - 199.9
1.0 mA	.000 - 1.999
10 mA	.00 - 19.99
100 mA	.0 - 199.9
1000 mA	0 - 1999

NOTE: When you measure current, your Multimeter will, to some degree, affect the operation of the circuit you are testing. This effect, known as "insertion loss" causes a voltage drop. To reduce this effect, use the highest measurement range possible that still gives you an accurate reading. Refer to "Specifications" on Page 113 for the amount of voltage drop for each range.

AC CURRENT MEASUREMENTS

NOTE: The AC converter in your Multimeter is an average-sensing circuit. When you measure AC current, any input other than a pure sine wave can cause an untrue reading. Square waves, sawtooth waves, etc., can be measured best with an oscilloscope.

1. Depress the AC and mA pushbuttons.

2. Set the RANGE switch to 1000, or to the desired lower range if it is known. CAUTION: Do not exceed three amperes of AC current on the 1000 mA range. If this is exceeded, a fuse will open, the display will read zero, and the circuit under test will be opened.

3. Plug the Multimeter test leads into the mA and C jacks. Then connect them to the circuit to be tested and observe the reading. Lower the setting of the RANGE switch until you reach the proper range. If the display flashes an overrange condition, switch to a higher range immediately as an overload condition exists. The following table shows the readout limits for each range.

RANGE	READOUT LIMIT
100 μA	0 - 199.9
1.0 mA	.000 - 1.999
10 mA	.00 - 19.99
100 mA	.0 - 199.9
1000 mA	0 - 1999

NOTE: When you measure current, your Multimeter will, to some degree, affect the operation of the circuit you are testing. This effect, known as "insertion loss" causes a voltage drop. To reduce this effect, use the highest measurement range possible that still gives you an accurate reading. Refer to "Specifications" on Page 113 for the amount of voltage drop for each range.

RESISTANCE MEASUREMENTS

1. Depress the DC/Ω and V/Ω pushbuttons.

2. Set the RANGE switch to the 1000 KΩ position, or to the desired range.

3. Plug the Multimeter test leads into the V/Ω and C jacks.

4. Connect the resistance to be measured to the test leads and observe the reading. Lower or raise the setting of the RANGE switch until you reach the proper range. The following table indicates the readout limits for each range:

RANGE	READOUT LIMIT
100	.0 - 199.9
1K	.000 - 1.999
10K	.00 - 19.99
100K	.0 - 199.9
1000K	0 - 1999

NOTE: The resistance circuits of the Multimeter are protected against AC and DC voltage inputs. For positive voltages (or peaks) up to 400 volts, a diode blocks the input. For negative voltages (or peaks) above about 30 volts, the V/Ω input fuse (F102) will open. When this happens, the Multimeter will show an overrange indication or an increasing count condition on all ranges, even with the test leads shorted together.

BATTERY OPERATION

You can operate the Multimeter from batteries when AC power is not available. With fully charged batteries (14 hours charge minimum), it should operate for approximately 8 hours. Although it may be operated continuously, it is recommended that the unit be turned off when not in use to conserve the batteries and prevent a complete discharge. Complete discharge of the batteries on a regular basis will result in shortened battery life and may also damage the individual cells.

Examine the state of charge of the batteries periodically with the RANGE switch. Place it in the BATT position and depress the DC/Ω and V/Ω pushbuttons. If the display reads less than 4.60, or fails to light, recharge the batteries. Should the nickel-cadmium batteries fail to charge, or if AC power is not available for charging, the unit may be operated on standard zinc-carbon or alkaline C-cell batteries. Zinc-carbon batteries will last up to 2 hours and alkaline batteries up to 6 hours.

NOTE: For any type of batteries, lower temperatures will shorten the operating time.

LINE VOLTAGE OPERATION AND CHARGING

The Multimeter may be connected to AC line voltage indefinitely for bench operation. The batteries charge when AC power is applied and the Multimeter is turned off. In the other RANGE switch positions, the charge level of the batteries remains about the same since the operating power is near the charging power. Therefore, the Multimeter should be turned off regularly so the batteries will stay fully charged for portable, or isolated from earth ground, operation.

If the batteries become discharged below 4.60, turn the Multimeter off and charge the batteries for at least 15 minutes before you use it. Full charge is restored after 14 hours of charging. Line voltage failure will not discharge the batteries when the Multimeter is turned off.

CAUTION: When the line cord is connected, never connect the Multimeter common lead to any voltage that is more than 1500 volts (1060 VAC) above earth ground. To do so will damage the Multimeter.

IN CASE OF DIFFICULTY

NOTE: It is important that you read the entire "General Troubleshooting Information" and "Troubleshooting Precautions" sections, which follow, before you attempt to service your Multimeter.

This section of the Manual is divided into three parts. The first part, titled "General Troubleshooting Information," describes what to do about the difficulties that may occur right after your Multimeter is assembled.

The second section, titled "Troubleshooting Precautions," points out the care that you should use when you service the Multimeter to prevent damage to components.

The third part, titled "Troubleshooting Chart," calls out specific problems that could occur and lists one or more conditions or components ("Possible Cause") that could cause each difficulty.

GENERAL TROUBLESHOOTING INFORMATION

WARNING: Observe the following precautions before you remove the cabinet from your Multimeter.

1. Disconnect the line cord.
2. Make sure the Range switch is in the OFF position.

If you intend to examine or service the logic circuit board, make sure you use the insulator tubing over the top edge of the front panel.

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.
2. About 90% of the kits that are returned for repair do not function properly because of poor soldering. Therefore, many troubles can be corrected by careful inspection of connections to make sure they are soldered as described in the "Soldering" section of the "Kit Builders Guide." Reheat any doubtful connections.
3. Closely examine each circuit board foil to see that no solder bridges exist between adjacent foils. If you are not sure a solder bridge exists, compare the circuit board foil with the "X-Ray Views" in the Manual. If a solder bridge exists, refer to the Assembly Notes on Page 7. Examine the component side of the circuit boards that have foil on both sides to check for solder that may have built-up on that side.
4. Make sure each transistor is in its proper location (correct part number and/or type number). Make sure each transistor lead is in the right hole and has a good solder connection to the foil.

5. Check the integrated circuits (IC's) for proper installation. Make sure the dot or marked (pin 1) end of the IC is over the dot on the circuit board. Check to see that each IC pin is in its socket connector and not bent out or under the IC.

6. Check each capacitor value. Make sure a capacitor of the correct value is installed at each capacitor location. Check electrolytic and tantalum capacitors to make sure the plus (+) marked lead is in the plus (+) marked hole on the circuit board.

7. Check each resistor value carefully. It would be easy, for example, to interchange a 22 kΩ resistor where a 220 kΩ resistor is called for. A resistor that is discolored, or cracked, or shows any signs of bulging would indicate that it is damaged and should be replaced. Since damaged resistors are often the result of some other difficulty (such as faulty wiring), you should try to find out what caused the damage before you replace the part.

8. Make sure the banded end of each diode is positioned correctly.

9. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

10. Check all component leads connected to the circuit board. Make sure leads do not extend through the circuit board and come in contact with other connections or parts.

If you still cannot locate and correct the trouble after you complete the above checks, and if a voltmeter is available, check the voltages in the Multimeter against the voltages shown on the "Schematic Diagram" and in the "Circuit Board Voltage Charts" at the rear of this Manual.

As a service aid, Pages 108 through 111 are drawings of the oscilloscope patterns to be expected at the designated points in the Multimeter circuit. In addition to an oscilloscope which can be set up for the time and voltage requirements designated, a high impedance, low capacitance probe will also be required.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Customer Service" information inside the rear cover of the Manual. Your Warranty is located inside the front cover.

TROUBLESHOOTING PRECAUTIONS

CAUTION: When you service or examine the logic circuit board, always make sure that you use the insulator tubing over the top edge of the front panel to prevent shorting foils. The Range switch should be OFF when you tighten or loosen this circuit board.

1. Make sure you do not short any adjacent terminals or foils when you make tests or voltage measurements. If a probe or test lead should slip, for example, and short together two adjacent connections, it is very likely to damage one or more of the transistors, diodes, or IC's.

2. Be especially careful when you test any circuit that contains an IC or a transistor. Although these components have an almost unlimited life when used properly, they are much more vulnerable to damage from excess voltage and current than many other parts.

3. In several areas of the circuit boards, the foil patterns are quite narrow. When you unsolder a part to check or replace it, avoid excessive heat while you remove the part. A suction-type desoldering tool makes part removal easier.

4. If you remove the LSI (IC201) DO NOT TOUCH IT TO ANYTHING that you are not already touching with your other hand. To do so may cause a static electricity charge that will damage the IC.

5. Avoid flexing the harness wires repeatedly. When you service the Multimeter, it is best to position the logic circuit board over the front panel and leave it there throughout the servicing procedure. Or lay the Multimeter on its side with the logic circuit board away from the front panel.

TROUBLESHOOTING CHARTS

The troubleshooting charts list conditions and possible causes of malfunctions. The first sections deal specifically with problems that may occur when you first turn the Multimeter on. Later sections deal with problems that may occur in specialized areas after the Multimeter is in operation. If a particular part or parts are mentioned (such as transistor Q2, or resistor R6) as a possible cause, check these parts to see if they are installed or wired incorrectly. Check to see if an improper part was installed at that location. It is also possible for a part to be faulty.

Some circuit boards have foil patterns on both sides. The "plated-through" holes carry the circuit from one side of the circuit board to the other. When you troubleshoot, make sure you check the circuit continuity through these holes.

Refer to Page 135 for IC basing diagrams and a cross reference table of Heath and manufacturer's numbers.

If you know the specific area of the problem, read through the following chart until you find the "Possible Cause" of the problem.

If you do not know the specific area of the problem, check the Multimeter for proper operation by using the list below to find the problem area. Then proceed to the "Troubleshooting Chart" to find the possible cause of the problem.

1. "BATT" position.
2. "+" DC on 100 mV position.
3. "–" DC on 100 mV position.
4. DC on 1.0 V position.
5. DC on 10, 100, and 1000 V positions.
6. Resistance positions.
7. AC on 100 mV position.
8. AC on 1.0 V position.
9. AC on 10, 100, and 1000 V positions.
10. Milliamperes positions.
11. Battery charging.

INITIAL TESTS PROBLEMS

PROBLEM	POSSIBLE CAUSE
Improper reading at Point 1.	Q223 improperly installed or defective.
Improper reading at Point 2.	1. Q229, C217, C218, C219. 2. Short in circuits connected to +5-volt supply.
Improper reading at Point 3.	1. D217, C232. 2. Short in circuits connected to +12-volt supply.
Improper reading at Point 4.	1. D218, C233. 2. Short in circuits connected to –12-volt supply.
Improper reading at Point 5.	1. D206, D207, D208, D209, C225, C226. 2. Short in circuits connected to +170-volt supply.
Improper reading at Point 6.	1. D215, D216, C229, C231. 2. Short in circuits connected to –170-volt supply.
Improper reading at Point 7.	1. Check wiring to battery clips and the terminal strip. 2. Switch assembly screws on SW5 touching mounting bracket.

INITIAL TURN-ON OR BASIC OPERATIONAL PROBLEMS

PROBLEM	POSSIBLE CAUSE
No part of the display lights in BATT, or any other position.	1. No battery voltage at E (emitter) of Q231. A. Battery E1 discharged, improperly installed, or not contacting battery holders. B. SW5H defective or wired incorrectly. C. Defective or wrong connection at AN, AT, AY, AZ, DH, or DI. D. L201 open or C221 shorted. 2. No +170-volt supply. A. Short circuit (solder bridges) on +170-volt line. B. Q231, Q232. C. T201. D. R297 to R302. E. D206 to D209. F. C222, C223, or C224. 3. No -170-volt supply. A. D215, D216. B. C229, C231. 4. Short circuit (solder bridges) on +12-volt or -12-volt lines. 5. IC201 not properly installed. 6. Q229. 7. R292. 8. C217, C218 shorted or reversed. 9. R423 and R424. 10. V401 and V402.

PROBLEM	POSSIBLE CAUSE
Only keep-alive* elements light in BATT, or any other position.	1. +12-volt and/or -12-volt supply read high or low. A. D211 to D214. B. C227, C228. C. Q233, Q234. D. R303, R304. E. D217, D218. F. Short on the +12-volt or -12-volt line. 2. +170-volt supply reads low. A. Q231, Q232. B. R297 to R302. C. D206 to D209. D. C223 to C226. 3. IC202 not properly installed.
8 lights brightly in one digit in BATT position with all other digits out.	1. Pin 4 of IC202 grounded. 2. IC202 defective.
1888 display on all ranges.	1. IC202 in backwards. 2. High or low supply voltage. 3. R255, R256. 4. C205.

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*The keep-alive elements are small, triangular elements near the bottom of the display tubes. These elements are covered by insulating paper.

PROBLEM	POSSIBLE CAUSE
+1 or -1 overrange in either 10.00, 100.0 or 1000 V/mA position.	1. AU to ground measures much greater than 100 kΩ. A. SW5E defective. B. R127, R128. 2. Check continuity (should be approximately zero ohms) from AU to DE. A. Open wiring to SW1B or SW4A. B. Poor connection at DE or defective wiring. 3. +12-volt or −12-volt supply low. 4. +5-volt supply low. 5. IC202 circuitry inoperative. A. R257 to R265. B. Remove transistors Q225 and Q228, and measure the DC voltage at pin 6 of IC202 while you rotate the Zero adjust through its full range. If there is no slow change in the voltage measurement when you rotate the Zero control, IC202 is defective. If you determine that IC202 is defective, replace Q225 and Q228 according to the instructions in the "Step-by-Step Assembly." If you have determined that IC202 is good, measure the DC voltage at pin 11 of IC201 while you rotate the Zero control through its full range. If the voltage measurement does not change, Q221, Q222, or the associated circuitry for these two transistors, is defective, Replace Q225 and Q228 according to the instructions in the "Step-by-Step Assembly." C. Q221, Q222. D. R266 to R269. E. C216.

(CONTINUED)

PROBLEM	POSSIBLE CAUSE
	6. Remove Q228 from the circuit. Then rotate the ZERO control through its full range. If the display does not change, Q225 or its associated circuitry is defective. After you perform this check, replace Q228. A. Q224, Q225. B R274 to R278. C. D203. 7. Remove Q225 from the circuit. Then rotate the ZERO control through its full range. If the display does not change, Q228 or its associated circuitry is defective. After you perform this check, replace Q225. A. Q226, Q227, Q228. B. R279 to R287. C. D204.
BATT position reads zero.	1. Check for battery voltage at the junction of R125 and the jumper wire. If no voltage is present, check the jumper wire and SW5F. 2. D202. 3. Q224, Q225. 4. R274 to R278.

PROBLEM	POSSIBLE CAUSE
BATT displays 3.00 to 8.00 but does not flash	1. D202. 2. SW5B defective. 3. Defective connections at CU or pins 2 and 3 of SW5B. 4. Pins 2 or 5 of IC201 not in socket.
Digits do not light, are dim, or appear to be pink.	1. V401 or V402 defective.
One or more digits do not light in BATT, or any other positions.	1. Appropriate digit driver circuit. 2. Pins 20, 21, 22, or 23 of LSI not in socket. 3. Defective or wrong connections at CL, CM, CN, CP, EH, EJ, EK, or EL. 4. AN1 to AN4 pins of V401, V402 not in socket.
One or more segments do not light in BATT, or any other position.	1. Appropriate Segment Driver circuit. 2. Pins 13, 14, 15, 16, 17, 18, or 19 of IC201 not in socket. 3. Defective or wrong connection at CA to CG, or EA to EG. 4. Segment pins of V401, V402 not in socket.
"–" does not light in 10.00 mA/V position with full travel of R257.	1. Q402. 2. R411, R412. 3. "–" pin of V401 not in socket. 4. Defective or wrong connection at CS, SW2D, or EP. 5. Pin 13 of IC201 not in socket.
"+" does not light in 10.00 mA/V position with full travel of R257.	1. Q403, R404. 2. R405 to R409. 3. "+" pin of V401 not in socket. 4. Defective or wrong connection at FG, SW5B, SW1F, or ES.

PROBLEM	POSSIBLE CAUSE
Decimal point does not light in BATT, or any other position.	1. Q401. 2. R414 to R417. 3. SW5A.
Decimal point does not light in one or more positions of the Range switch.	1. SW5A. 2. Defective or wrong connection at CH, CI, CJ, EX, DY, EZ, FA, or FF. 3. DP of AN2, AN3, or AN4 not in socket.
One or more digits light in BATT but do not light in 1 mA/V position with input shorted.	1. Q233. 2. R271 to R273. 3. Defective or wrong connection at CT or ET.
Display is zero or near zero in all Range switch positions.	1. Q218, Q219. 2. C212, C213. 3. Rotate the Zero control (R257) from fully counterclockwise to fully clockwise. If the display does not change, check capacitor C215. 4. SW1C, SW3D, SW4D, SW5D. 5. Defective or wrong connection at AV.
Display "Skips" zero.	1. IC201 defective.
Display on BATT is erratic.	1. IC201 defective. 2. C214, C215, C218, C219, C232, or C233. 3. Clock frequency far from 50 kHz. Check "Calibration."

DC VOLTAGE PROBLEMS

PROBLEM	POSSIBLE CAUSE
Overrange or increasing count, on 100 mV and 1.0 V positions with test leads shorted, while higher ranges read zero.	1. Push mA. If readout then indicates zero, fuse F102 is open. 2. R132. SW3D, 3. SW5E, SW1B, SW4A, SW1E, SW3B, SW4D, or SW1C, or associated wiring.
Cannot adjust R277 for "+ TP REF" number or to laboratory standard.	1. D203 defective. 2. Q218, Q219 leaky or improperly installed. 3. +12-volt supply low. 4. Clock frequency too low. 5. R277, R278. 6. "+ TP REF" number in error. 7. R305, R306, R307, D217.
Cannot adjust R287 for "- TP REF" number or to laboratory standard.	1. D204 defective. 2. Q218, Q219 leaky or improperly installed. 3. -12-volt supply low. 4. R286, R287. 5. "-TP REF" number in error. 6. R308, R309, R311, D218.
Minus 1.9-volt input different than plus 1.9-volt input by more than 10 counts after DC calibration.	1. Q225 or Q228 leaky. 2. Q218, Q219 leaky or improperly installed. 3. C212, C213 leaky.

PROBLEM	POSSIBLE CAUSE
Nonlinearity (using laboratory standards).	1. Clock frequency too low. 2. C215. 3. Q218, Q219 leaky or improperly installed. 4. IC202 defective.
Inoperative on 10, 100, and 1000 V positions only.	1. Defective (broken or poorly soldered) "JUMPER." 2. SW2C, SW5D, SW5E. 3. R125 to R128.
10-volt, 100-volt, and 1000-volt full-scale readings inaccurate.	1. R125 to R128.
Inoperative on 1000-volt position only.	1. R129.
Erratic or "noisy" readings during "floating" operation.	1. C1.

RESISTANCE PROBLEMS

All Resistance positions show over-range or increasing count with shorted input.	1. F102 open. 2. R123. 3. SW1A, SW5F, SW5E. 4. Defective or wrong connection at AP.
All Resistance positions read zero with open input.	1. D105, D106. 2. R124, R204. 3. Q201. 4. D201. 5. Defective or wrong connection at BC, DF, or DG.

PROBLEM	POSSIBLE CAUSE
Cannot adjust R401 for "1900 REF" number or to laboratory standards.	1. R401, R402. 2. D201. 3. SW5B. 4. Defective or wrong connection at FB, FD, or SW5B. 5. "1900 REF" number in error. 6. R293.
Cannot adjust R403 for "19 K REF" number or to laboratory standard.	1. R403, R404. 2. SW5B. 3. Defective or wrong connection at FE or SW5B. 4. "19 K REF" number in error. 5. R294.
Cannot adjust R202 for "190 K REF" number or to laboratory standard.	1. R201, R202, or R203. 2. Defective or wrong connection at DG or SW5B. 3. "190 K REF" number in error. 4. R295.
Cannot obtain reading near "1.8 M REF" number after 100 kΩ position calibration.	1. Q218, Q219 leaky or improperly installed. 2. C212, C213 leaky. 3. Q201 leaky or defective. 4. C114. 5. D106. 6. R296. 7. "1.8 M REF" number in error.
Display shows several counts on 100.0 Ω position, but zero on others with test leads shorted.	1. This is normal and, due to test lead resistance, it may be either subtracted from other readings or "cancelled" with ZERO control R257.

AC VOLTAGE PROBLEMS

PROBLEM	POSSIBLE CAUSE
Inoperative on all AC voltage positions.	1. Q101, Q102. 2. IC101. 3. D101 to D104. 4. R101 to R103, R105, R109, R112 to R115, R118, R119, or R122. 5. C101, C107, C113. 6. SW1B, SW2A.
Difference between 100 mV and 1.0 V full-scale readings.	1. R104, R105. 2. Q101. 3. R111. 4. C108, C109. 5. SW4B, SW5G. 6. Defective or wrong connection at AE, AR.
Frequency response of 100 mV and 1.0 V positions is not "flat" at 10 kHz using laboratory standards.	1. C102 to C106. 2. IC101. 3. R107, R108. 4. C103. 5. SW1E.
AC HI (C117) or AC LO (C119) adjustments cannot be made.	1. C117, C119. 2. C116, C118, C121, C122. 3. R130.
100 mV, 1V, and 10V positions show counts with open input or when measuring in high impedance circuitry.	1. This is normal due to the high input impedance and sensitivity of the AC circuitry. Operate the Multimeter on batteries only, and use shielded cable or twisted pair wiring. 2. R131. 3. SW1D.

PROBLEM	POSSIBLE CAUSE
All positions show nonzero display with input shorted.	1. ZERO control misadjusted. 2. R106. 3. C101, C107. 4. C108, C109.
"Drifting" count from full-scale reading on 100 mV and 1.0 volt positions with full-scale inputs applied.	1. C101, C108.

mA PROBLEMS

Inoperative on all positions, DC or AC input (reads zero).	1. F101 open. 2. R133. 3. SW3A and SW3C, SW4E, SW5C, or SW4C. 4. Defective or wrong connections at AA, AD, or AX.
Shows counts on mA with leads shorted, but not on volts.	1. D107 to D111 incorrectly installed, leaky, or open.
Displays low or high on all ranges.	1. D107 to D111 shorted. 2. SW4F. 3. R134 to R138.
Displays overrange in circuit, but zero with shorted leads.	1. R134 to R138 open. NOTE: If you find an open resistor, also check for an open diode D107 to D111.
Display is correct on DC but in error on AC. AC volts display is correct.	1. R139, R141. 2. SW2B.

BATTERY CHARGING PROBLEM

PROBLEM	POSSIBLE CAUSE
Battery fails to charge (BATT reading shows no increase when AC is connected).	1. D112. 2. T1. 3. E1. 4. R1. 5. F1. 6. Defective or wrong connection of transformer jumpers or wiring. NOTE: The resistance between lugs 2 and 3 of the AC socket should measure between 250 Ω and 350 Ω if your kit is wired for 120-volt operation. The resistance should be approximately 1400 Ω if your kit is wired for 240-volt operation.
Battery fails to hold a charge.	1. E1. 2. D112 leaky.

OSCILLOSCOPE WAVEFORMS

To check for the presence of the following waveforms, you will need a DC-coupled oscilloscope with vertical calibration from .5 V/cm to 50 V/cm and time base (horizontal) calibration of 5 μs/cm, 10 μs/cm, 1 ms/cm, and 20 ms/cm. Use a high impedance, low-capacitance probe with the oscilloscope.

To check for the presence of the following waveforms, use a DC-coupled oscilloscope capable of the time and voltage settings required. Use a high impedance, low-capacitance probe with the oscilloscope.

1. Set the Multimeter to the BATT position.
2. Connect the common lead of the oscilloscope to the common lead of the Multimeter.
3. Adjust the oscilloscope for the designated time and voltage settings for the waveform to be observed.
4. Connect or touch the oscilloscope probe tip to the test point and compare the pattern on the oscilloscope to the one in the photograph.

Read the following notes before you perform the waveform tests.

A. Waveform 1 requires only the +5-volt supply and an operating DC-to-DC converter.

B. Waveforms 2 and 3 require only the +5 and -12-volt supplies and basic operation of IC201.

C. Waveforms 4 to 8 require proper operation of IC201, IC202, and the + REF current source.

D. Waveforms 9 to 11 require proper operation of the digit drivers, the segment drivers, and the +170-volt supply.

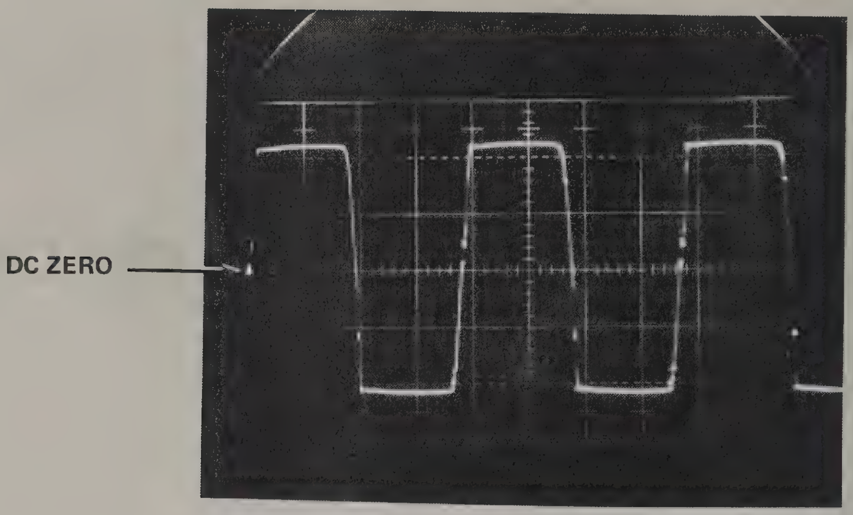
E. Due to the "flashing" type display on BATT, all waveforms may "pulse" in frequency or amplitude at the flash rate.

F. These waveforms correspond to the positive (+) voltage during the BATT test. Some waveforms will vary with different voltage levels or polarity.

G. The small, white dot on each waveform indicates the vertical DC zero (reference) level.

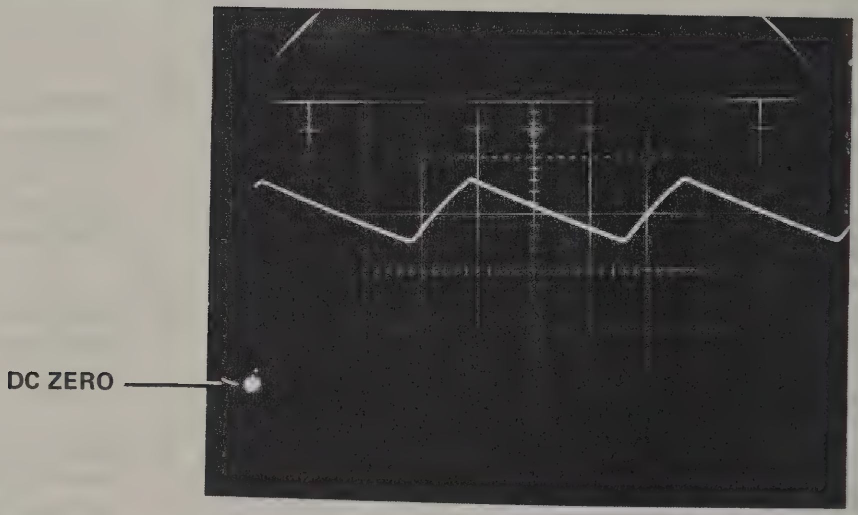
I

Time/cm: 10 μs
Volts/cm: 2V
Test Point: C (collector) of Q231, Q232
Comment: Typical waveform, frequency may vary due to load, etc.



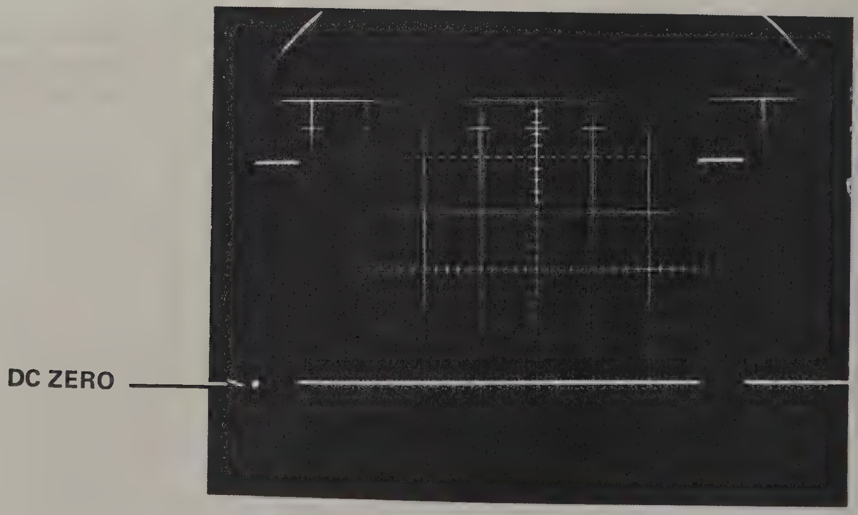
II

Time/cm: 5 μs
Volts/cm: 1V
Test Point: Pin 4 of IC201



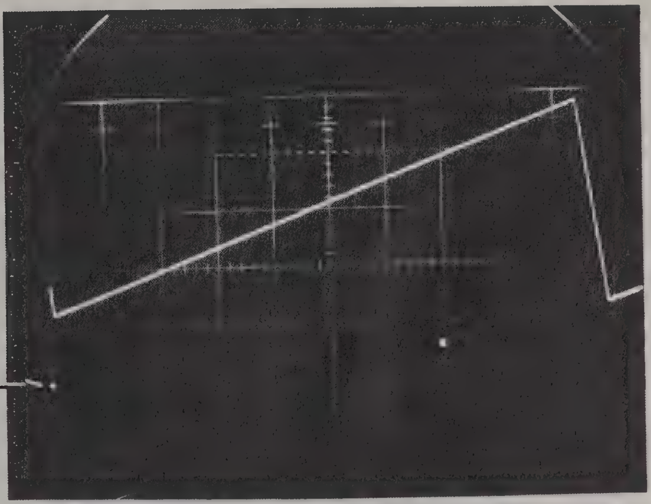
III

Time/cm: 1 ms
Volts/cm: 1 V
Test point: Test loop at FA (pin 20 of IC201)
Comment: Pins 21 to 23 similar.



IV

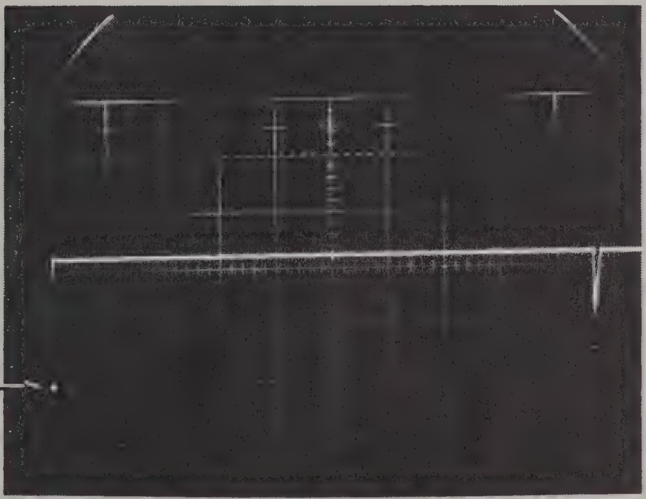
Time/cm: 20 ms
Volts/cm: 0.5 V
Test point: Pin 6 of IC202
Comment: Peak point proportional to input voltage.



DC ZERO

V

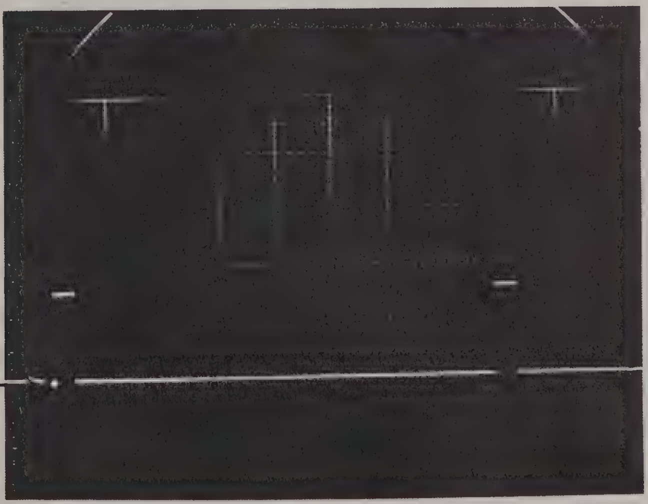
Time/cm: 20 ms
Volts/cm: 2 V
Test point: Pin 11 of IC201



DC ZERO

VI

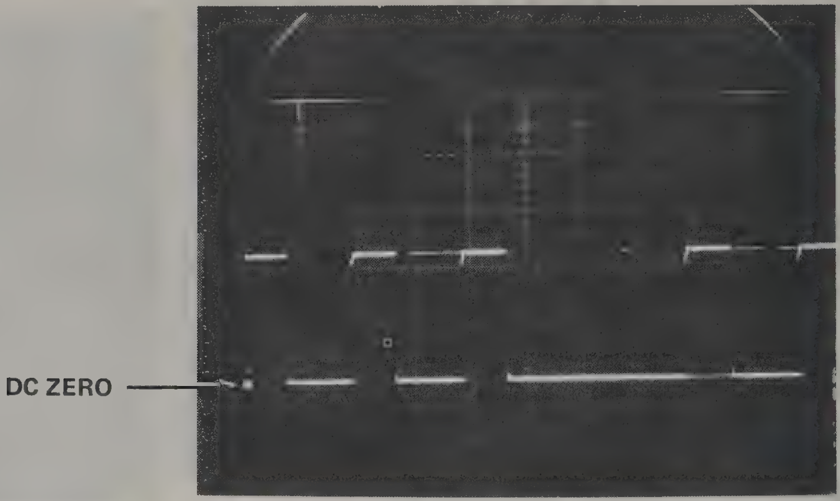
Time/cm: 20 ms
Volts/cm: 0.5 V
Test point: Pin 10 of IC201



DC ZERO

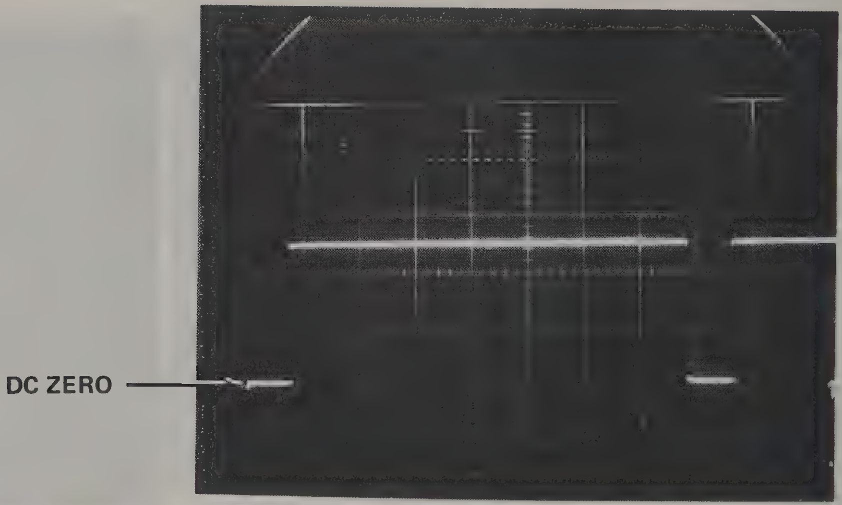
VII

Time/cm: 1 ms
Volts/cm: 2 V
Test point: Pin 17 of IC201
Comment: Number of pulses per display time depends on display; may be 0, 1, 2, 3, or 4 per display time. Similar on Pin 13 to 16, 18, 19.



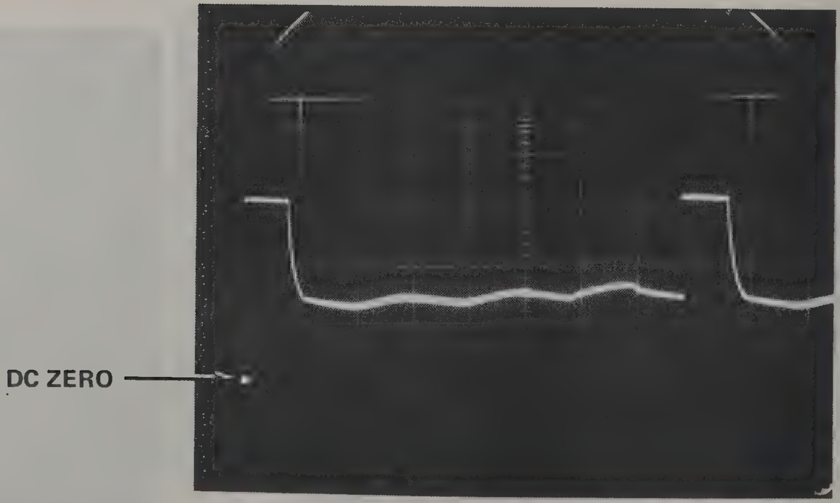
VIII

Time/cm: 1 ms
Volts/cm: 2 V
Test point: Pin 6 of IC201
Comment: None on 1000 V and 1000K position.



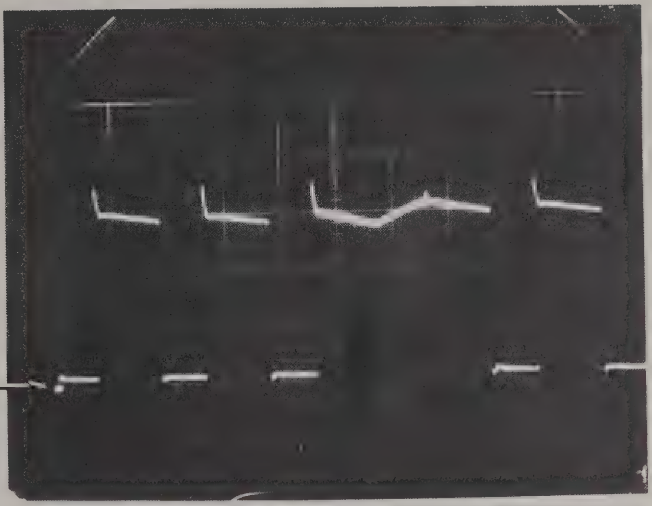
IX

Time/cm: 1 ms
Volts/cm: 50 V
Test point: C (collector) of Q209
Comment: Same on Q203, Q205 Q207.



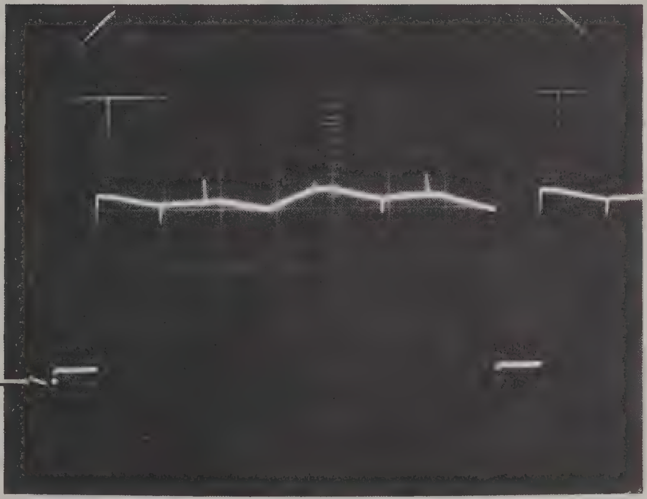
X

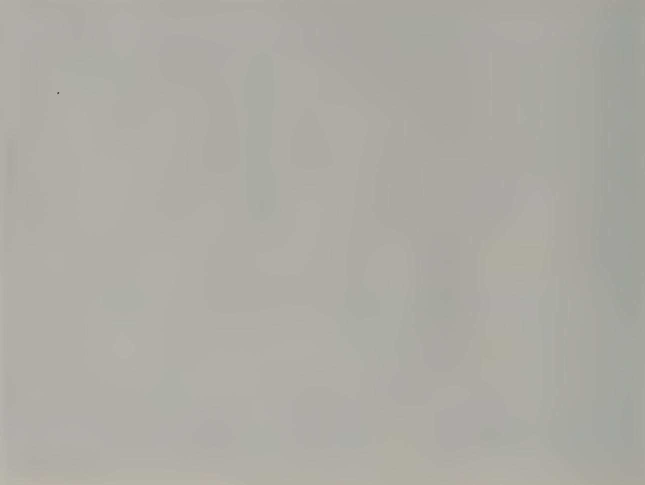
Time/cm:	1 ms
Volts/cm:	20 V
Test point:	C (collector) of Q213
Comment:	Number of pulses per display time depends on display; may be 0, 1, 2, 3, or 4 per display time similar on Q211, Q212, Q214 to Q217.

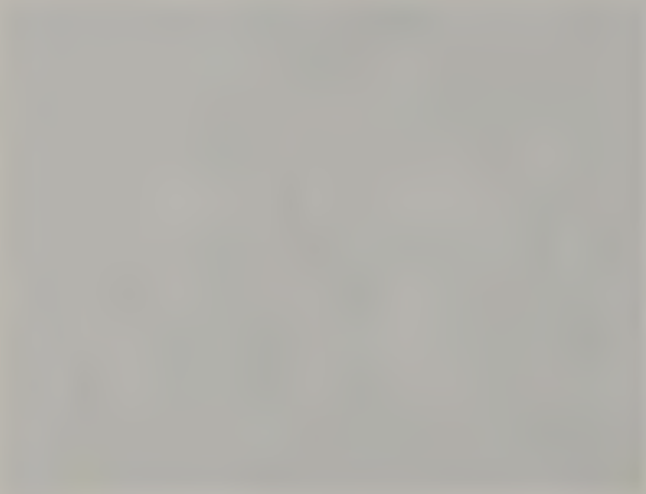


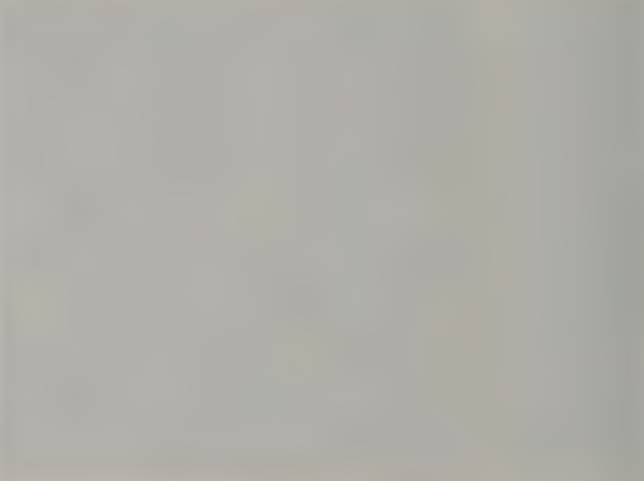
XI

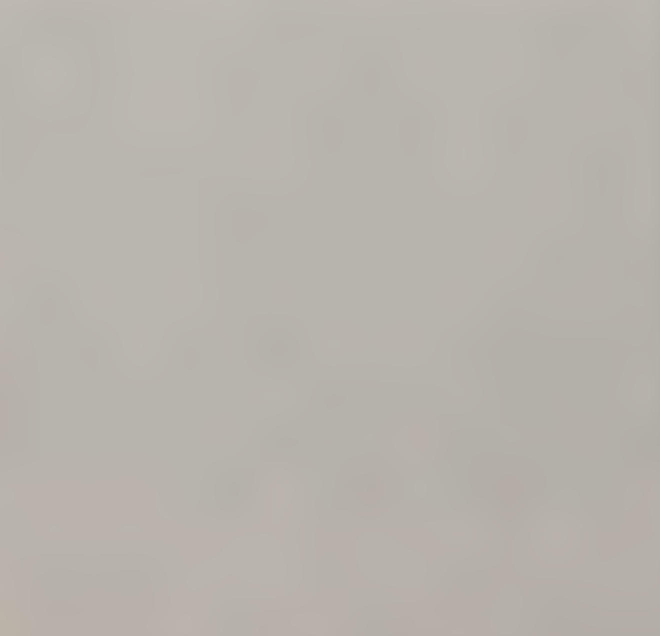
Time/cm:	1 ms
Volts/cm:	20 V
Test point:	C (collector) of Q401
Comment:	None of 1000 V and 1000K positions.











SPECIFICATIONS

NOTE: The Accuracy of this Multimeter depends on whether you calibrated it using the Built-In References, or using Laboratory Standard References. Specifications are listed for both methods of calibration.

DC VOLTS

RANGE	INPUT IMPEDANCE	OVERRANGE CAPABILITY	OVERLOAD CAPABILITY
100.0 mV	50 MΩ	100%	300 VDC
1.000 V	500 MΩ	100%	300 VDC
10.00 V	10 MΩ	100%	1000 VDC
100.0 V	10 MΩ	100%	1000 VDC
1000 V	10 MΩ	None	1000 VDC

Accuracy	Built-in References: ±0.5%, ±1 digit. Laboratory Standards: ±0.2%, ±1 digit.
Temperature Coefficient	±200 PPM/°C.

AC VOLTS

RANGE	IMPEDANCE	OVERRANGE CAPABILITY	OVERLOAD CAPABILITY
100.0 mV	10 MΩ/120 pF	100%	250 VAC
1.000 V	10 MΩ/120 pF	100%	250 VAC
10.00 V	10 MΩ/60 pF	100%	750 VAC
100.0 V	10 MΩ/60 pF	100%	750 VAC
750 V	10 MΩ/60 pF	None	750 VAC

Accuracy	Built-in References: ±1.5%, ±3 digits, from 50 Hz to 1 kHz (except 50 Hz to 10 kHz on 100 mV and 1 V ranges). Laboratory Standards: ±.75%, ±3 digits, from 50 Hz to 10 kHz (except ±1.0%, ±3 digits, from 50 Hz to 2 kHz on 750 VAC range).
Temperature Coefficient	±500 PPM/°C.

DC MILLIAMPERES

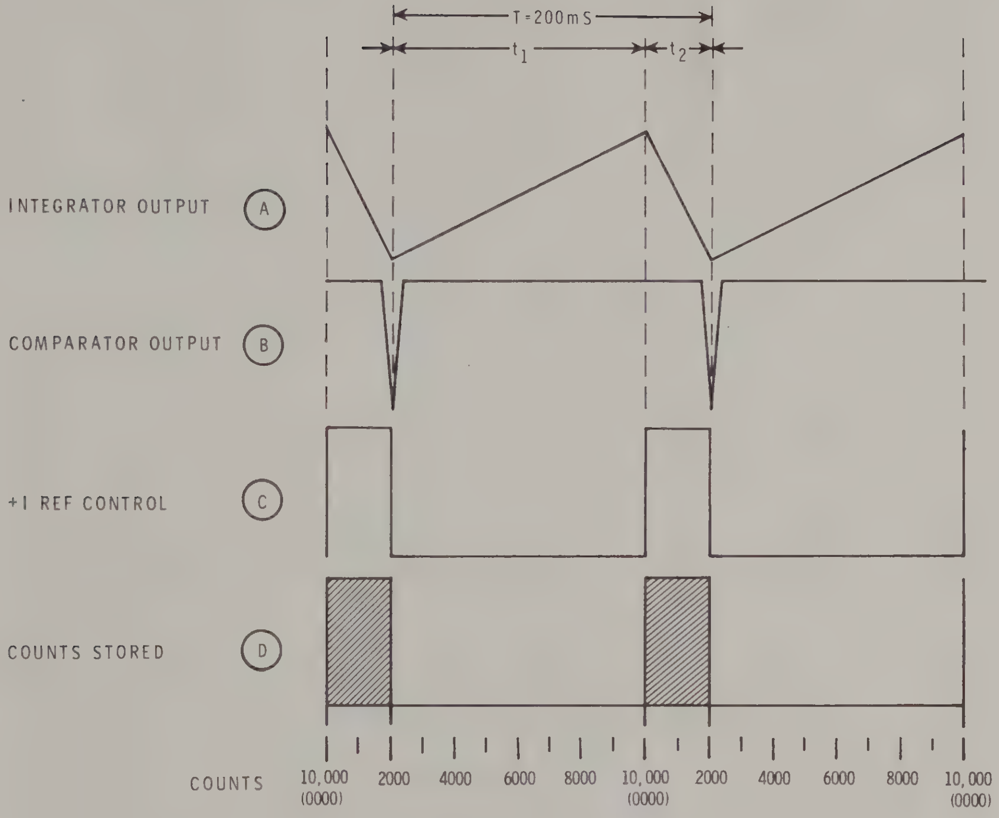
RANGE	VOLTAGE DROP (Approximate)	OVERRANGE CAPABILITY
100.0 µA	100 mV	100%
1.000 mA	100 mV	100%
10.00 mA	100 mV	100%
100.0 mA	150 mV	100%
1000 mA	300 mV	100%

Accuracy	Built-in References: ±0.5%, ±1 digit (except ±1.0%, ±1 digit on 1000 mA range). Laboratory Standards: ±0.2%, ±1 digit (except ±0.5%, ±1 digit on 1000 mA range).
Temperature Coefficient	±250 PPM/°C.
Overload Protection	Input coupled through 3.0 ampere fuse to shunt diodes for overloads above approximately 1.2 volts.

AC MILLIAMPERES

RANGE	VOLTAGE DROP (Approximate)	OVERRANGE CAPABILITY
100.0 µA	100 mV	100%
1.000 mA	100 mV	100%
10.00 mA	100 mV	100%
100.0 mA	150 mV	100%
1000 mA	300 mV	100%

Accuracy	Built-in References: ±1.0%, ±3 digits from 50 Hz to 10 kHz (except ±1.5%, ±3 digits on 1000 mA range). Laboratory Standards: ±0.5%, ±3 digits from 50 Hz to 10 kHz; (except ±1.0%, ±3 digits on 1000 mA range).
Temperature Coefficient	±550 PPM/°C.
Overload Protection	Input coupled through 3.0 ampere fuse to shunt diodes for overload above approximately 1.2 volts.



WAVE FORMS
Figure 8

DC MILLIAMPERES

RANGE	VOLTAGE DROP (Approximate)	OVERRANGE CAPABILITY
100.0 μA	100 mV	100%
1.000 mA	100 mV	100%
10.00 mA	100 mV	100%
100.0 mA	150 mV	100%
1000 mA	300 mV	100%

Accuracy . . . . Built-in References: ±0.5%, ±1 digit (except ±1.0%, ±1 digit on 1000 mA range).

Laboratory Standards: ±0.2%, ±1 digit (except ±0.5%, ±1 digit on 1000 mA range).

Temperature Coefficient . . . . ±250 PPM/°C.

Overload Protection . . . . Input coupled through 3.0 ampere fuse to shunt diodes for overloads above approximately 1.2 volts.

AC MILLIAMPERES

RANGE	VOLTAGE DROP (Approximate)	OVERRANGE CAPABILITY
100.0 μA	100 mV	100%
1.000 mA	100 mV	100%
10.00 mA	100 mV	100%
100.0 mA	150 mV	100%
1000 mA	300 mV	100%

Accuracy . . . . Built-in References: ±1.0%, ±3 digits from 50 Hz to 10 kHz (except ±1.5%, ±3 digits on 1000 mA range).

Laboratory Standards: ±0.5%, ±3 digits from 50 Hz to 10 kHz; (except ±1.0%, ±3 digits on 1000 mA range).

Temperature Coefficient . . . . ±550 PPM/°C.

Overload Protection . . . . Input coupled through 3.0 ampere fuse to shunt diodes for overload above approximately 1.2 volts.

RESISTANCE

RANGE	TEST CURRENT	OVERRANGE CAPABILITY
100.0 Ω	1.0 mA	100%
1.000 kΩ	1.0 mA	100%
10.00 kΩ	0.1 mA	100%
100.0 kΩ	1.0 μA	100%
1000 kΩ	1.0 μA	100%

Accuracy	Built-in References: ±0.5%, ±1 digit. Laboratory Standards: ±0.2%, ±1 digit.
Temperature Coefficient	±300 PPM/°C.
Open-Circuit Voltage	12 VDC.
Overload Protection	Positive input overvoltage protection by blocking diode to 400 volts; negative input overvoltage through 1/32-ampere fuse and shunt diode.

GENERAL

Display	1999 Maximum; seven segment planar; 0.55" high digits.
Polarity Indication	Automatic "+" and "–".
Overrange Indication	Automatic above 1999; polarity sign and decimal point shown with flashing "1" in thousands.
Display Rate	Approximately 5 per second, nonblinking.
Normal Mode Rejection	35 dB (line operation); extended on battery operation.
Common Mode Rejection	80 dB (line operation); extended on battery operation.
Power Line Isolation	May be operated 1500 V above power line ground (during line operation).
Operating Temperature Range	10°C to 40°C (50°F to 104°F).
Storage Temperature Range	-40°C to 50°C (-40°F to 122°F) with batteries installed, -40°C to 70°C (158°F) with batteries removed.

Power Requirements	110 to 130 VAC, or 220 to 260 VAC (internally selectable); 50/60 Hz; 5 watts typical during charge.
Operating Time	8 hours typical after 14 hours minimum charge time (from internal nickel-cadmium batteries). Standard "C" batteries may be used for intermittent operation up to 2 hours for Zinc-Carbon (NEDA type 14) and up to 6 hours for Alkaline (NEDA type 14A). Built-in "Battery Test" function provided.
Size (overall, including handle folded to rear)	3" high x 8-1/4" wide x 8" deep. (76.8 MM high x 211.2 MM wide x 204.8 MM deep).
Weight	4-1/2 lbs (2.04 Kg).

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 137), the Block Diagram in Figure 7, and the waveforms in Figure 8 (fold-out from Page 116) while you read the following description.

To help you locate parts in the Meter and on the Schematic, the resistors, capacitors, and other components are numbered in the following groups:

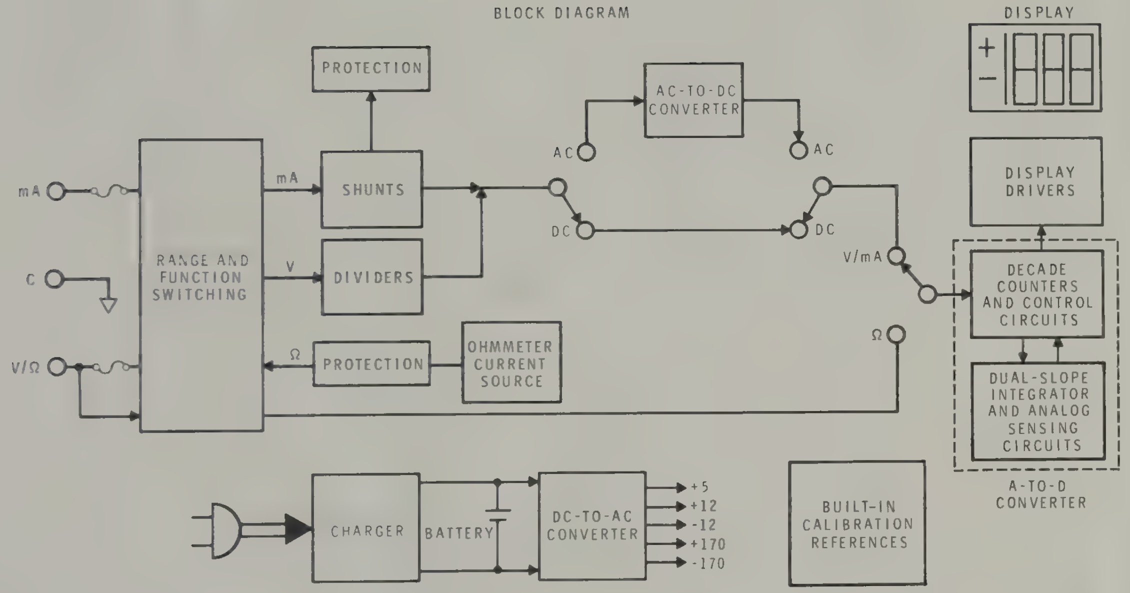
1-99	Chassis mounted parts.
100-199	Parts mounted on the input circuit board.
200-399	Parts mounted on the logic circuit board.
400-499	Parts mounted on the display circuit board.

Selected inputs of resistance, current, or voltage to be measured are directed through the Function switch and scaling networks to the input of the A-to-D (analog-to-digital) converter. (AC inputs, after scaling, are directed through an AC-to-DC converter before they are applied to the A-to-D converter.) The scaling and the AC-to-DC conversion converts all inputs to a proportional DC voltage which is then measured by the A-to-D converter.

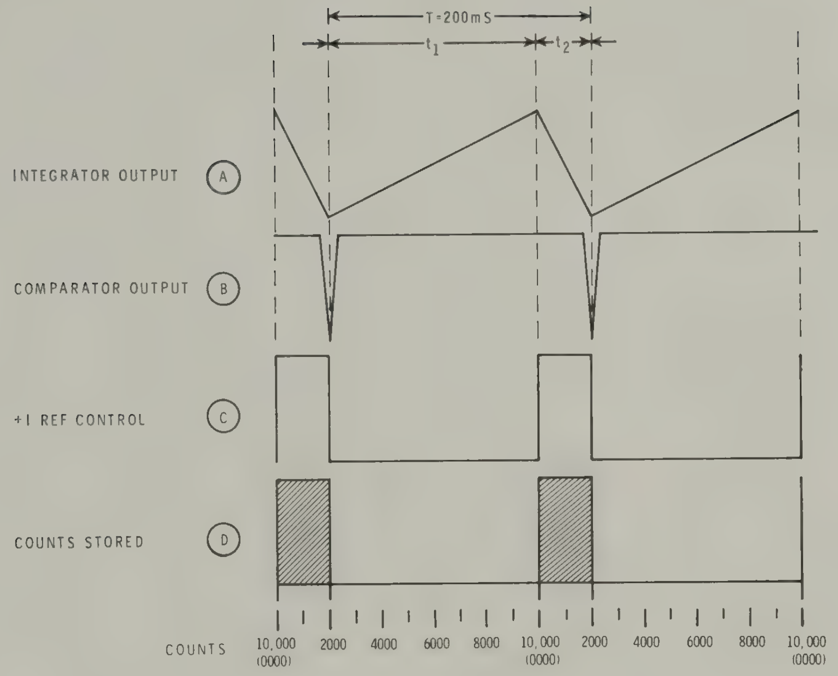
The A-to-D converter integrates the input DC voltage during a fixed time period. This time period allows a clock oscillator to generate a number of pulses which are directly proportional to the DC input level. After passing through the decade counters and the decoder driver circuits, the number of gated pulses from the clock oscillator is displayed by the digital readout tubes.

Multisection switches provide decimal point switching, polarity indicator switching, input ranging, gain changing in the A-to-D converter, etc.

This Multimeter is basically a DC voltmeter. Therefore, the circuitry that digitally measures DC voltages will be explained first in the A-to-D Converter section. When the description deals in polarity, a positive input signal will be assumed. Circuits that pertain to negative input signals are also described.



BLOCK DIAGRAM
Figure 7



WAVE FORMS
Figure 8

Power Requirements	110 to 130 VAC, or 220 to 260 VAC (internally selectable); 50/60 Hz; 5 watts typical during charge.
Operating Time	8 hours typical after 14 hours minimum charge time (from internal nickel-cadmium batteries). Standard "C" batteries may be used for intermittent operation up to 2 hours for Zinc-Carbon (NEDA type 14) and up to 6 hours for Alkaline (NEDA type 14A). Built-in "Battery Test" function provided.
Size (overall, including handle folded to rear)	3" high x 8-1/4" wide x 8" deep. (76.8 MM high x 211.2 MM wide x 204.8 MM deep).
Weight	4-1/2 lbs (2.04 Kg).

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CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 137), the Block Diagram in Figure 7, and the waveforms in Figure 8 (fold-out from Page 116) while you read the following description.

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200-399	Parts mounted on the logic circuit board.
400-499	Parts mounted on the display circuit board.

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This Multimeter is basically a DC voltmeter. Therefore, the circuitry that digitally measures DC voltages will be explained first in the A-to-D Converter section. When the description deals in polarity, a positive input signal will be assumed. Circuits that pertain to negative input signals are also described.

A-to-D CONVERTER

The A-to-D converter consists mainly of a dual-slope integrator (IC202) and two constant-current sources as shown in Figure 9. As shown in waveform A on Figure 8, the output of the integrator goes up during time t_1 due to a positive input at E_{in}. At the end of time t_1, counters inside IC201 reset to zero and turn on one of the constant current sources that drives IC202 in the opposite direction. During this down-slope time (see waveform D) the pulses inside IC201 are counted. The pulse count is then stored and displayed until the next measurement is made.

Full-scale input voltages to the integrator are either 100 millivolts or 1 volt (1000 mV). With 100 mV DC applied to E_{in}, and with switch SW5G closed in the 100 mV position, IC202 will produce just enough voltage at point Y to force the necessary current to flow through C215 and R to balance the Ⓧ input of IC202 at 100 millivolts. To maintain the necessary current flowing through R, point Y must keep going higher in voltage to overcome the charging of C215. This corresponds to the up-slope of t_1. If, in this instance, R equals 2500 Ω, then 40 μA will flow through it to balance the 100 millivolts at E_{in}.

If 1.0 volt (1000 mV) is applied, which is ten times the previous input, and switch SW5G is open, the resistance from point Ⓧ to ground is ten times the previous resistance. Thus, the same amount of current will flow, and the integrator output will change as before.

In the above example, IC202 supplies 40 μA to change C215 during time t_1 of waveform A. At the end of time t_1, the positive constant current source turns on and supplies 400 μA to discharge C215 during time t_2. Therefore, C215 will discharge at a 360 μA rate (400 μA reference – 40 μA input = 360 μA discharge). How the correct polarity of current is selected, to discharge C215 to zero, will be discussed later.

The slope during time t_2 is always the same. However, a higher input voltage will cause a steeper t_1 slope. This means the t_2 down slope will take longer, more pulses will be counted, and a higher voltage count will be displayed.

If the input to the integrator had been negative, its output would have been negative, and the negative constant current source would have been turned on by IC201 at the end of t_1.

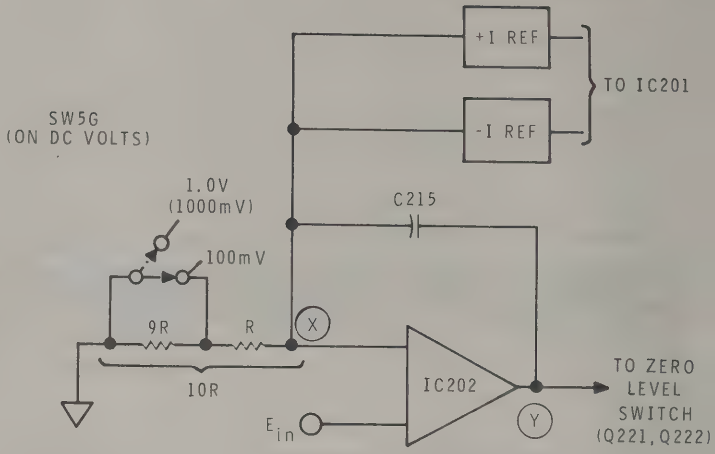


Figure 9

Constant Current Sources

Figure 10 shows the positive constant current source.

At the beginning of time t_2 the positive current (+I) output of IC201 turns on Q224. Then current flows through D203 and R275, Q225A, and R276, and R274 to ground through Q224. D203 is a transistor connected as a temperature-stable zener diode. Q225A is connected as a diode and its base-to-emitter voltage is added to the voltage of D203 at the base of Q225B. The emitter voltage of Q225B is exactly the same as the zener voltage of D203 because the base-emitter voltages cancel. Therefore, the current through R277 and R278 is constant since the current depends only on the constant voltage at D203 and the constant total resistance of R277 and R278. When Q224 is off, no current can flow through D203, Q225A, or Q225B.

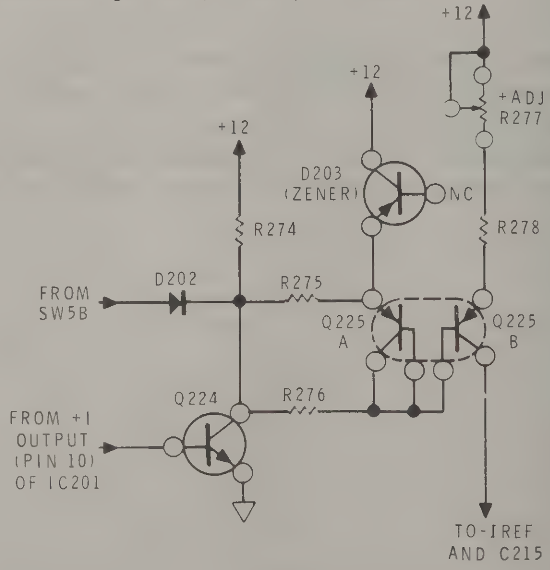


Figure 10

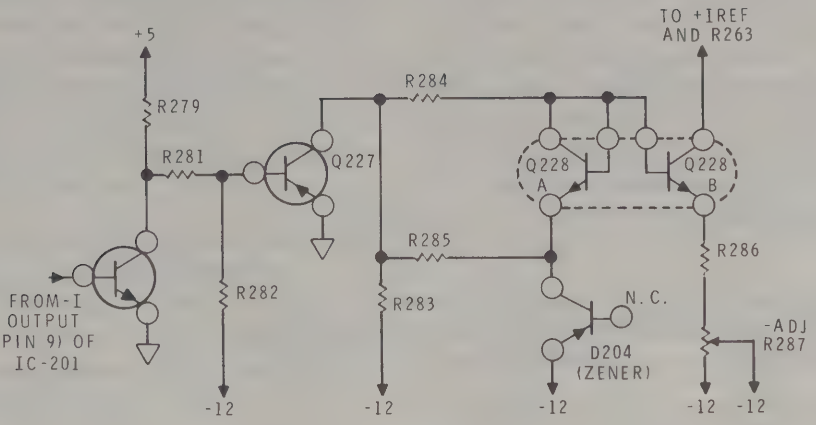


Figure 11

The operation of the negative constant current source shown in Figure 11 is similar to the positive source except for an additional inverting transistor, Q226.

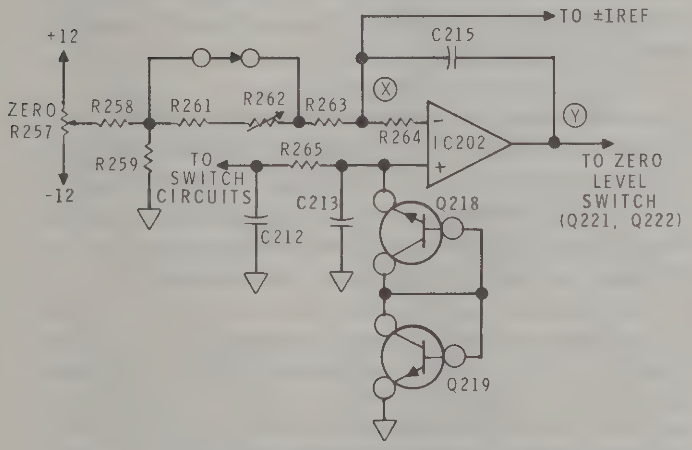


Figure 12

A-to-D Input Filtering, Protection, and Zeroing

The circuit in Figure 12 is used at the input of IC202. The C212, R265, C213 network (along with resistors from the various switch circuitry) forms a low-pass filter that removes transient and AC signals from the integrator input. Q218 and Q219 act as diode clamps to limit any accidentally applied overvoltages. For positive overvoltages, the emitter-base junction of Q218 breaks down at about 6 volts and the forward-biased base-emitter junction of Q219 conducts. For negative overvoltages, the opposite occurs. Current through the junctions is limited by R265 and the other series resistances from the switch circuits.

Even with no input, offset voltages in IC202 (unless compensated) will produce a continuous ramp at point Y and the display will stabilize at some reading other than zero. To compensate, the ground end of the integrating resistor network (R261 to R263) is connected to an adjustable, low-impedance source consisting of R257 to R259. This appears as a ground connection, although the zeroing circuitry is implied.

R259 and its associated resistors provide a voltage source which can be adjusted to compensate for about 8 millivolts of offset voltage in IC202. Different voltage ranges do not require a change in this adjustment.

R264 provides approximately balanced DC source impedances at each input of IC202 to minimize any temperature-related changes in the input bias current of IC202.

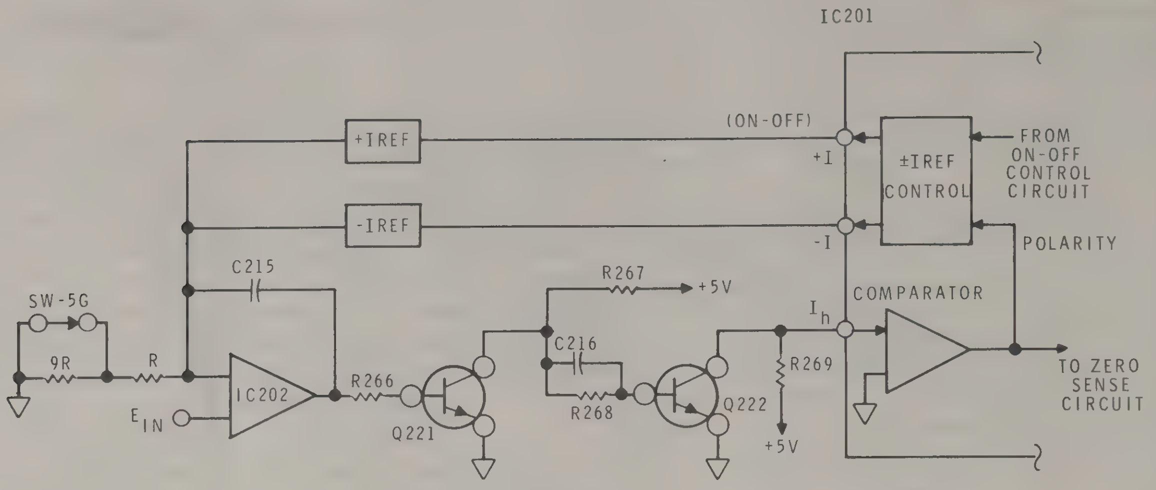


Figure 13

Analog Sensing Circuitry

The circuitry which "measures" the DC voltage and senses polarity is shown in Figure 13.

For explanation purposes, assume that a measurement of +100 mV has just been completed. At this point, several things have just occurred.

First, the +I REF current source has discharged C215 to a point where a "zero" level has been reached. Second, the internal counters have just advanced to a count of 1000. This count and its polarity has been stored and will be displayed during the remainder of the measurement cycle. Third, the "ON/OFF" control line to the ± I REF control circuit in IC201 has just turned off both current sources. This allows integrator IC202 to start charging C215 at a rate determined by E_{in}.

After some time, the internal count reaches 9999. At this count, the collector of Q222 is positive. This high, at this count, forces the internal comparator output polarity to be high. This selects the +I REF as the proper discharge current source to be turned on. At the next count of 10000, the four-decode internal counters overflow to a count of 0000. The overflow signal activates the ± I REF control line and turns on the + I REF current source to discharge C215. The integrator then ramps down from its peak voltage. When it crosses "zero", the new measurement count is again stored and displayed. The waveforms of the integrator output, comparator output, I REF control signal, and the counts stored are shown in A, B, C, and D of Figure 8 to illustrate the time relationship. Should the input voltage change, the peak voltage will change and result in a shorter or longer "count" time (t_2).

If the input had been negative at the 9999 count, the output of IC202 would have been negative. This would cause Q221 to be off and the collector of Q222 to be low and force the internal comparator output low. This low would select the I REF as the proper current source to be turned on. When the counters overflow to 0000, it is turned on and charged C215 from its negative peak back to the "zero" level.

COUNT CONTROL AND DISPLAY CIRCUITRY

The oscillator inside IC201 is capacitively tuned to 50,000 Hz by capacitors C207, C208, C209, and C211. This frequency is then divided inside IC201 to produce the 5 Hz measurement cycle rate (200 milliseconds) and is used for other timing functions.

The number counted and stored in IC201 is displayed in a multiplexed manner. The outputs of IC201 activate the proper digit and segments of that digit for a short time, and then activate another digit and its proper segments, etc., until the number is displayed. This action happens at such a rapid rate that each digit appears to be on continually.

The leading zero-blanking circuit (inside IC201) receives a pulse from Q223, which is driven by SW5A. This pulse indicates that a decimal point is to show in that digit. The location of the decimal point is used as an input to IC201 so that zeros to the left of the decimal point are not turned on unless they are needed.

The overrange circuit is also inside IC201. If a pulse produced inside IC201 at reset time occurs before a pulse from an internal frequency divider, the circuit detects a legitimate measurement, and the measurement is displayed. However, if the pulses occur in the reverse order, the overrange circuit is activated — which blanks out the lowest three digits of the display and flashes a 1 in the left digit.

DISPLAY DRIVE CIRCUITRY

The circuits of Q211 through Q217, Q401, Q402, and Q404 use current regulation to maintain brightness over the normal battery voltage range. Each transistor base is pulled to a fixed voltage when that segment is to be turned on. The emitter voltage is initially low before the display lights. When the display lights, the emitter voltage increases to a point where any further increase would tend to turn the base-emmiter junction off (reverse-bias it). The collector-emitter voltage changes as required to maintain the emitter voltage at the proper level.

Transistors Q202 through Q209 act as electronic switches to connect the proper display anode (AN) to +170 volts.

The collectors of Q211 to Q217, Q401, Q402, and Q404 have pull-up resistors which provide a bias voltage (center of R255, R256) to speed up the display turn-off time.

Assume that a 3 is to be displayed in the AN2 position, as in a display of +1.137. (See Figure 14, fold-out from Page 121.) The P2 output of IC201 goes high, turning on Q206 and Q207. This causes AN2 to be pulled to +170 volts. At the same time, the A, B, C, D, and G outputs of IC201 go high, turning on Q211, Q212,Q213, Q214, and Q217. This allows current to flow through AN2 and the A, B, C, D, and G segments of this digit and form a 3. Just after the 3 is displayed, Q208 and Q209 turn on to activate the AN1 digit while Q211, Q212, and Q213 also turn on. This action displays the 7. After the 7 is displayed, Q202 and Q203 turn on while Q211 and Q212 turn on. This action displays the 1. Additional circuitry is activated to display the + symbol and the decimal point. In this position, SW5A connects the P4 output of IC201 to turn on Q401, which turns on the decimal point. Also, at this time, due to the internal polarity detection circuitry of IC201, the G output of IC201 is not energized and Q402 and Q403 are off. Since Q403 is off, it provides current to turn on Q404. This action lights the + symbol. If the G output had been high (from a negative input), Q402 and the – symbol would have turned on. With Q403 also on, Q403's low collector voltage would keep Q404 and the + symbol off.

For an AC function, the switches shown in Figure 14 ground the base of Q402 and open the base circuit of Q404, holding both the + and – symbols off since there is no polarity associated with AC signals. The measuring circuits in the following sections condense the A-to-D and display drive circuits into the basic meter circuit shown in Figure 15.

DC VOLTAGE MEASURING CIRCUIT

When you measure DC voltages, the input is controlled by the Range and Function switch circuit as shown in Figure 15. NOTE: All capacitors and unlabeled resistors shown in Figure 15 affect only the AC voltage measuring circuit. They are shown for the sake of future discussion, and have no effect on DC measurements.

On the 1000-volt, 100-volt, and 10-volt ranges, the input voltage applied to the V/Ω input is applied through fuse F102 to the voltage divider circuit of R125, R126, R127, and R128 through SW1C, SW3D, SW4D, and SW5D. On the 1000-volt range, with 1000 volts applied, for example, the divider network produces exactly 1.0 volt at the top of R128. This voltage is then applied through R129, SW5E, SW4A, and SW1B to the input of the basic meter circuit. The Sensitivity switch (SW5G in this function) is open in this position, producing a 1.0 volt sensitivity. The sign switch is in the Auto position so that the polarity of the input voltage is displayed.

On the 100-volt range with 100 volts applied, the divider network produces 1.0 volt at the top of R127. The sensitivity remains in the 1.0 volt position.

On the 10-volt range with 10 volts applied, the divider produces 0.1 volt at the top of R127. The Sensitivity switch is now closed and the sensitivity of the basic meter circuit is 0.1 volt.

For the 1.0-volt and 100-millivolt ranges, the input is applied through R132 and a series of switches directly to the basic meter circuit. The Sensitivity switch is open on the 1.0-volt range and closed on the 100-mV (0.1 volt) range. In these positions, R132 is inserted to provide additional overvoltage protection for the integrator. The decimal point on these ranges produces displays of 1000, 100.0, 10.00, 1.000, and 100.0 (millivolts) on the five voltage ranges.

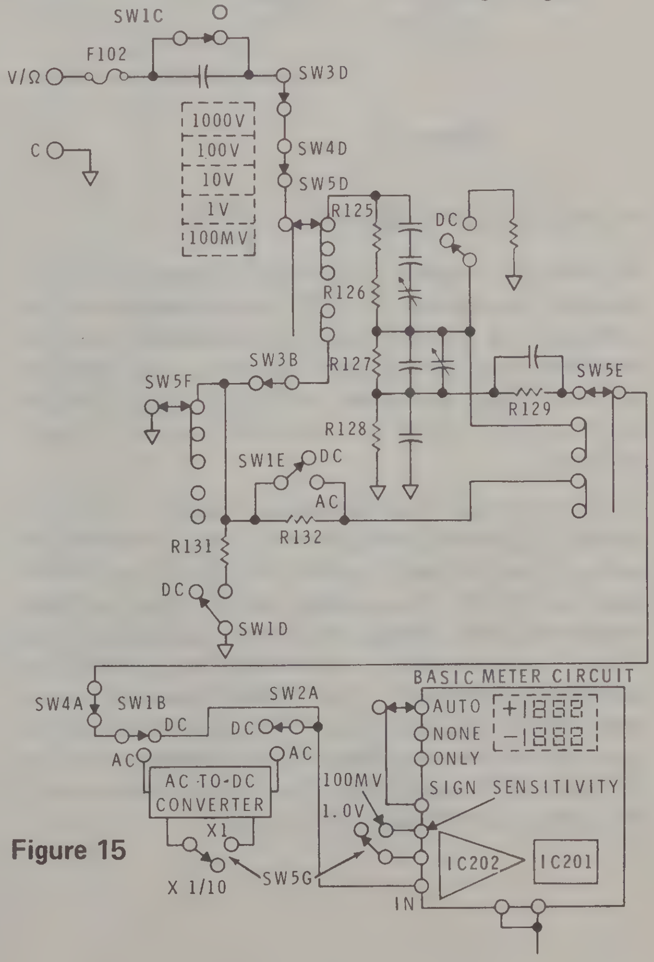
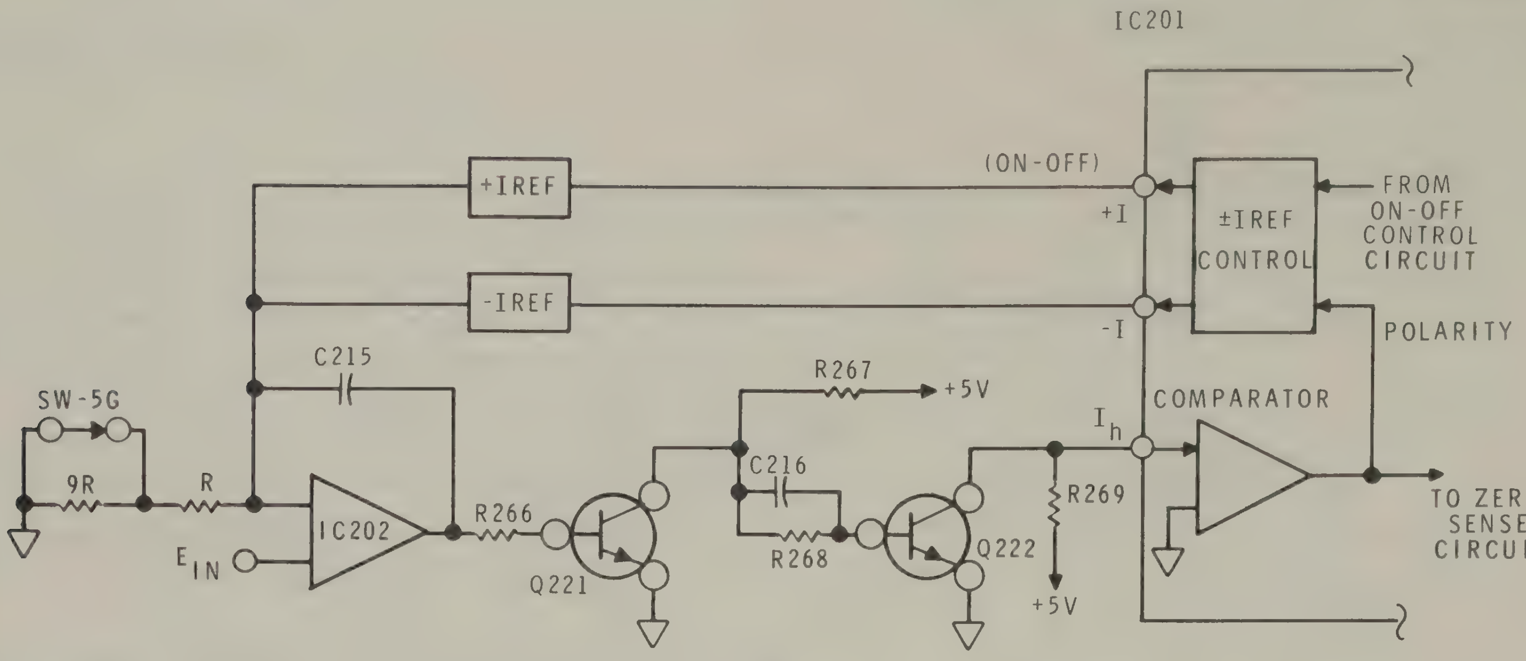


Figure 15



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After some time, the internal count reaches 9999. At this count, the collector of Q222 is positive. This high, at this count, forces the internal comparator output polarity to be high. This selects the +I REF as the proper discharge current source to be turned on. At the next count of 10000, the four-decode internal counters overflow to a count of 0000. The overflow signal activates the ± I REF control line and turns on the + I REF current source to discharge C215. The integrator then ramps down from its peak voltage. When it crosses "zero", the new measurement count is again stored and displayed. The waveforms of the integrator output, comparator output, I REF control signal, and the counts stored are shown in A, B, C, and D of Figure 8 to illustrate the time relationship. Should the input voltage change, the peak voltage will change and result in a shorter or longer "count" time (t_2).

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On the 100-volt range with 100 volts applied, the divider network produces 1.0 volt at the top of R127. The sensitivity remains in the 1.0 volt position.

On the 10-volt range with 10 volts applied, the divider produces 0.1 volt at the top of R127. The Sensitivity switch is now closed and the sensitivity of the basic meter circuit is 0.1 volt.

For the 1.0-volt and 100-millivolt ranges, the input is applied through R132 and a series of switches directly to the basic meter circuit. The Sensitivity switch is open on the 1.0-volt range and closed on the 100-mV (0.1 volt) range. In these positions, R132 is inserted to provide additional overvoltage protection for the integrator. The decimal point on these ranges produces displays of 1000, 100.0, 10.00, 1.000, and 100.0 (millivolts) on the five voltage ranges.

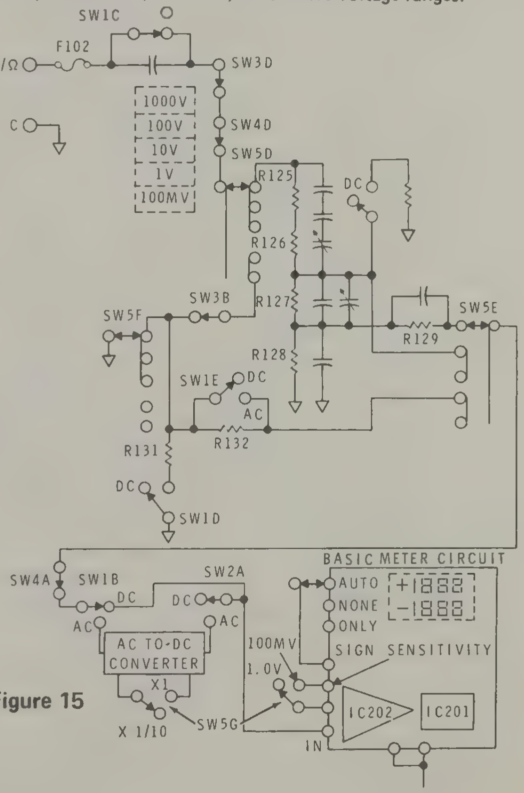


Figure 15

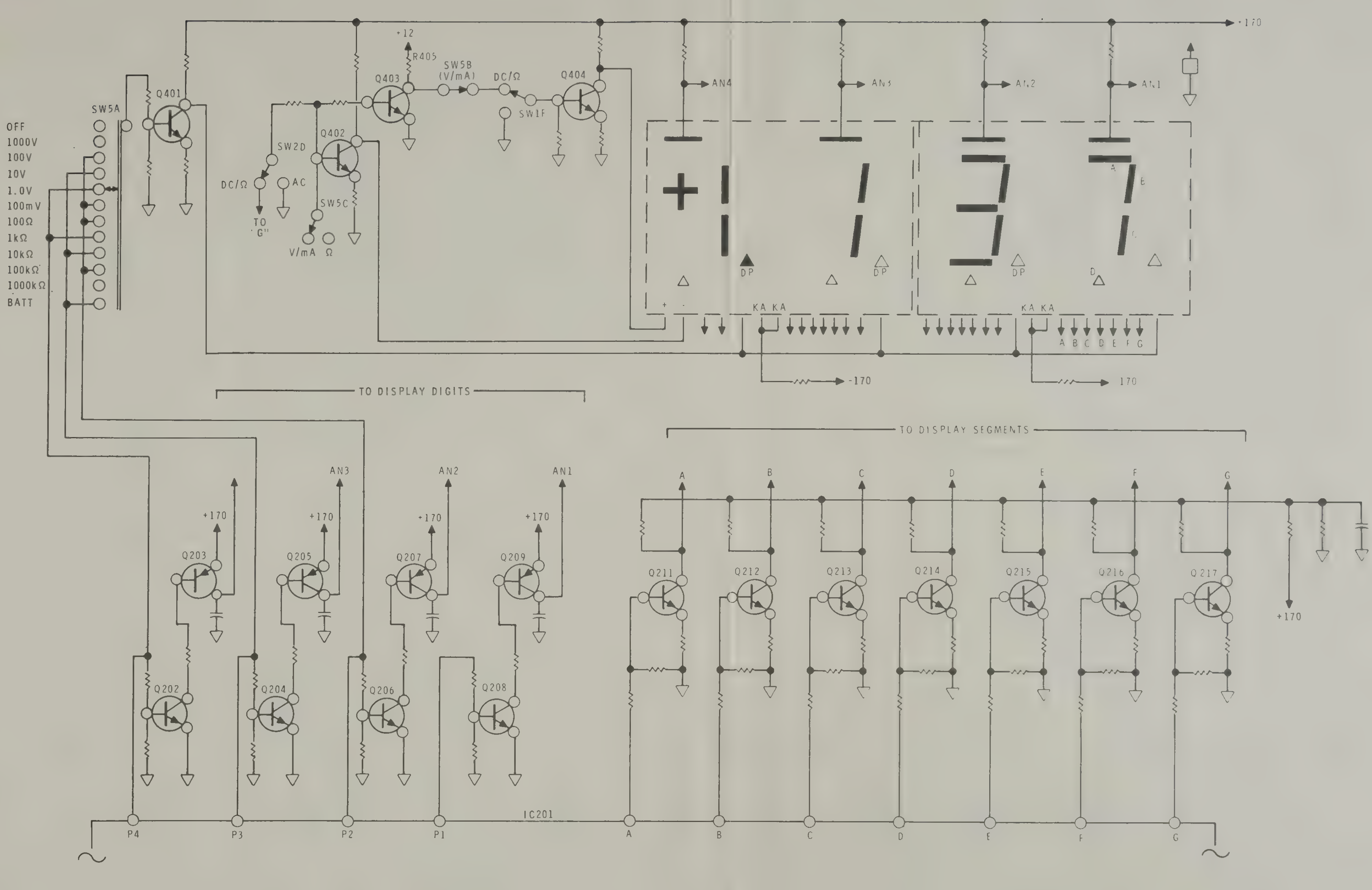


Figure 14

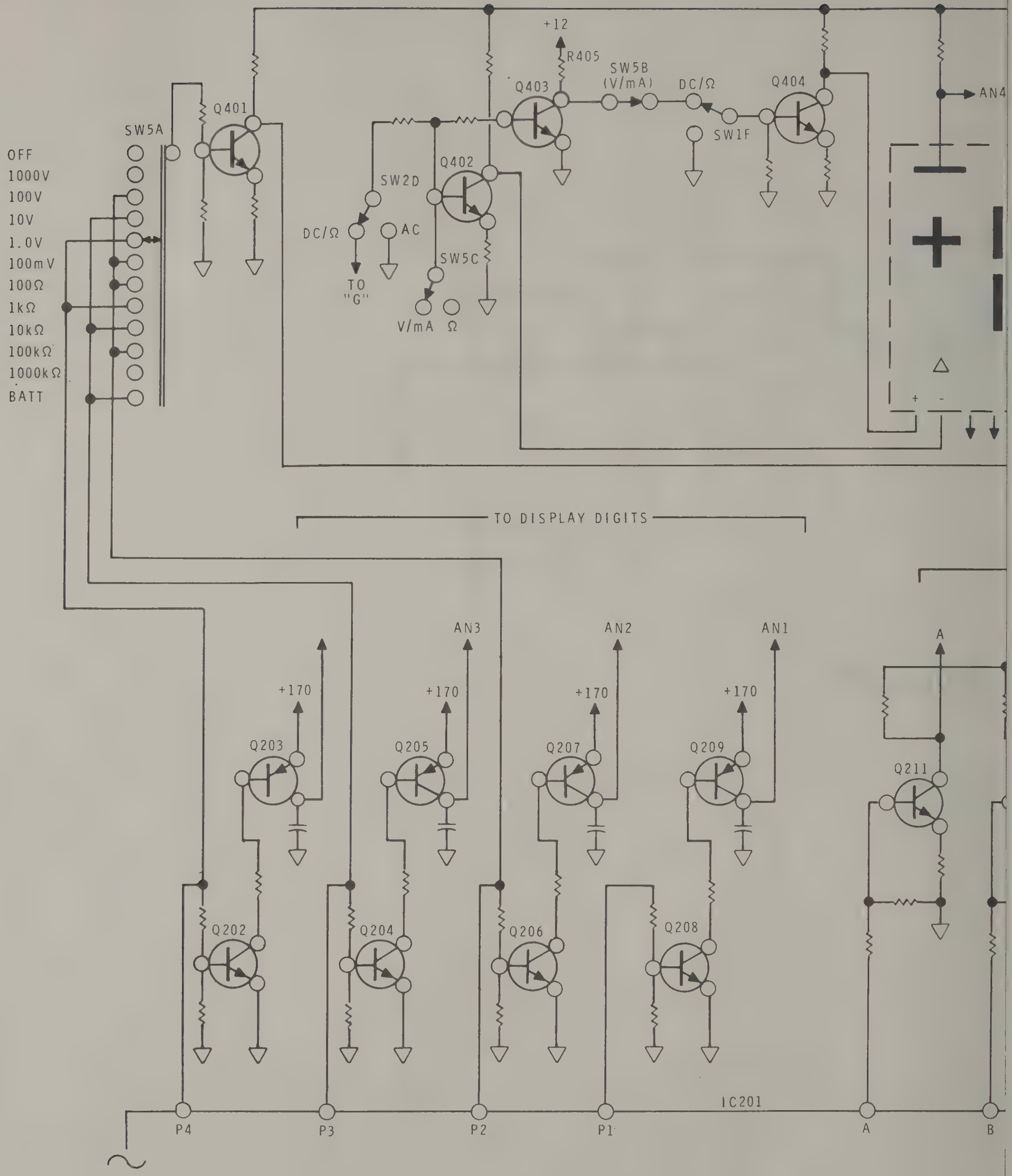

+12
R405
SW5B
(V/mA)
DC/Ω
Q404
AN4
Q403
Q401
SW5A
OFF
1000V
100V
10V
1.0V
100mV
100Ω
1kΩ
10kΩ
100kΩ
1000kΩ
BATT
SW2D
Q402
DC/Ω
AC
TO
"G"
SW5C
V/mA
Ω
SW1F
+
-
TO DISPLAY DIGITS
AN3
AN2
AN1
A
+170
+170
+170
+170
Q203
Q205
Q207
Q209
Q211
Q202
Q204
Q206
Q208
IC201
P4
P3
P2
P1
A
B

Figure 14

On the 100 μA range, the input current applied to the mA input flows through F101, SW3A and SW3C, SW4E, and SW5C; then through R134, R135, R136, R137 and R138, and returns to the C (common) input. On this range, the total resistance of the sensing resistors is 1000 Ω. When 100 μA (0.1 mA) flows through these resistors, there is a voltage drop of 0.1 volt. This voltage is coupled through R133 (which serves as overload protection), and then through SW4C and SW1B to the input of the basic meter circuit. SW4F selects the 100 millivolts sensitivity position for both DC and AC currents, and the decimal point is also switched as required.

For DC measurements, the sign switch is in the "AUTO" position. For AC measurements it is in the "NONE" position, while SW1B and SW2A switch in the AC-to-DC Converter.

Diodes D107 through D111, and resistors R139 and R141 form overload protection for the current-sensing resistors. Normally, the common connection of D107 and D108 is less than 0.2 volts DC (0.28 volts peak AC). The anode of D107 and the cathode of D108 are held at -0.7 volts and +0.7 volts respectively since D109 and D111 are forward-biased by R139 and R141. These voltages cause D107 and D108 to be normally reverse-biased, presenting a high impedance. If an overload occurs and the voltage drop exceeds 1.2 volts, either positive or negative, either D107 or D108 becomes forward-biased. Since the series impedance is low, a high current will flow. When the current exceeds the rating of F101, the fuse will open and disconnect the input.

RESISTANCE MEASURING CIRCUIT

Resistance measurements are accomplished by passing a precision, constant current through the unknown resistance and then measuring the voltage produced. See Figure 18.

On the 100 Ω range, the precision 1 mA current flows from the ohmmeter current source through R124, D105, SW5D, SW4D, SW3D, SW1C, F102, and Rx to C (common) as shown in Figure 18. The voltage generated across Rx is coupled through R123, SW5F, SW5E, SW4A, and SW1B to the basic meter circuit. The Sensitivity switch (part of SW5G) is closed to the 100-millivolt position, and the sign switch is in the None position. On the 1 kΩ range, the Sensitivity switch opens to the 1.0-volt position. The 1.0-volt is produced by the 1 mA of current flowing in the full-scale 1000 Ω.

On the 10 kΩ ranges, the precision current is 100 μA. On the 100 kΩ and the 1000 kΩ ranges the current is 1 μA.

Diode D105 protects the precision current source from any high positive voltage applied to the input. For negative overvoltages, diodes D105 and D106 are forward-biased and cause F102 to open. R124 limits current through the diodes for any transient negative voltages.

OHMMETER CURRENT SOURCE

The ohmmeter current source works in a slightly different manner from the ±I REF circuits.

In the 100 Ω position, the emitter of Q201A is biased by D201 while R401 and R402 determine the current through Q201B. This current source, 1 mA, is the same for both the 100 Ω and 1 kΩ positions while the basic meter circuit changes sensitivity for the 100 mV and 1.0 V produced.

On the 10 kΩ position, R402 and R404 set this current source at 100 μA.

On the 100 kΩ and 1 MΩ positions, due to the extremely low current of 1 μA, the circuit is controlled by fixed resistor R201, returning to a variable source (R202 and R203). This allows a wide, yet stable, adjustment range.

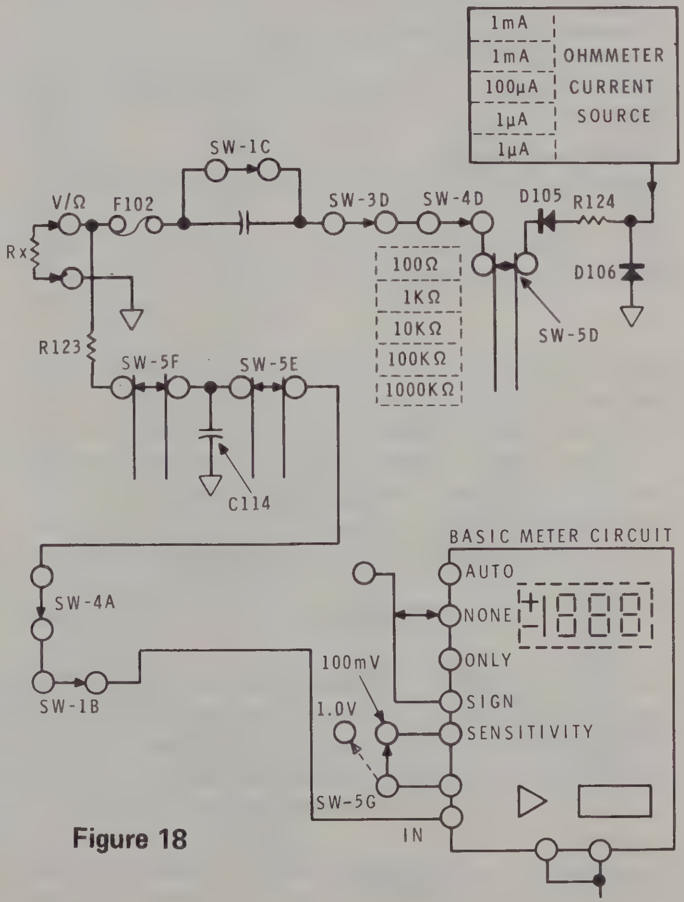


Figure 18

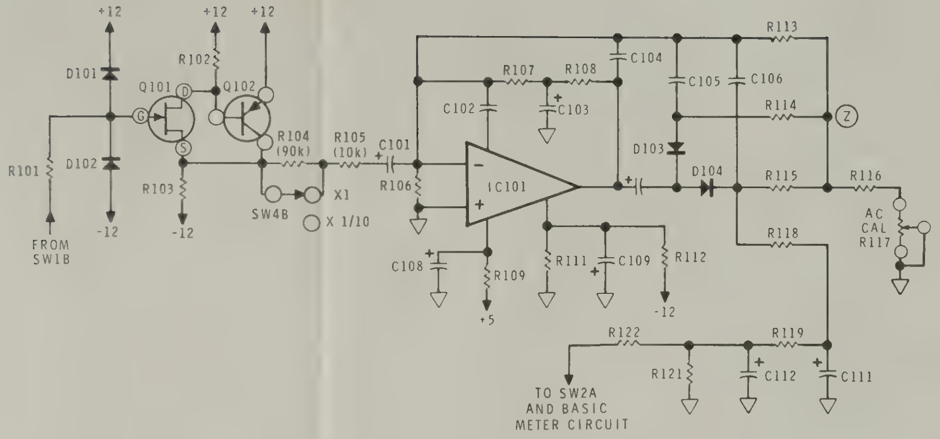


Figure 20

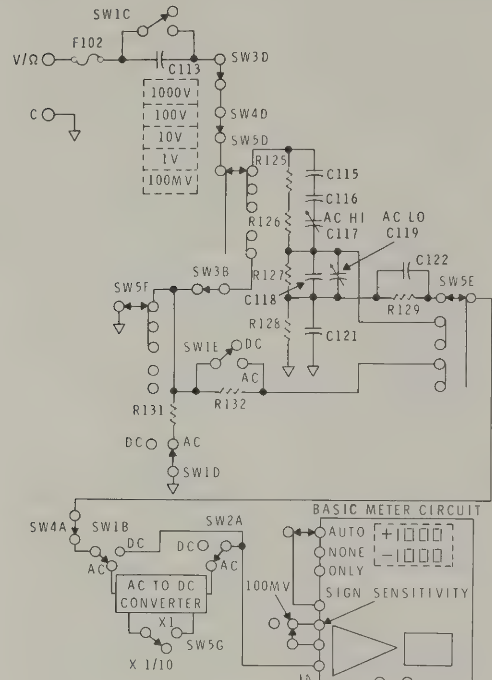


Figure 16

AC VOLTAGE MEASURING CIRCUIT

The circuit for measuring AC voltages is shown in Figure 16. Its operation is similar to the DC voltage measuring circuits except that the capacitors and unlabeled resistors mentioned previously now affect the operation, the AC-to-DC Converter Circuit is inserted, and certain slightly different switching takes place, as described in the following paragraphs.

The input voltage is applied through fuse F102 and then through C113 to the voltage divider circuit. C113 blocks DC (and very low-frequency) signals. The divider functions the same as for DC measurements except that, at higher frequencies, C115 through C121 act as capacitive voltage divider "compensation." C122-R129 also extend the high-frequency response of the 100-volt range. On all AC ranges, R132 is shorted out so it does not attenuate the AC signal. On the two low ranges, R131 is connected into the Circuit by SW1D to provide a 10 MΩ input impedance on these ranges, lowering stray-voltage pickup.

After the input switching, the signal is applied to the AC-to-DC Converter — an FET-input, average-responding, RMS-calibrated circuit. Its DC-voltage output is directly proportional to the input or to 1/10 of the input voltage. The action of the X1, X1/10 switch (part of SW5G) is similar to that discussed for DC. It is in the X1/10 position on the 1000-volt, 100-volt, and 1.0-volt ranges and in the X1 position on the 10-volt and 100-millivolt ranges. The Sensitivity switch on the basic metering circuit is held in the 100-millivolt sensitivity position by SW5B for all AC ranges.

The sign switch is closed to the None position to blank out the + and — symbols of the display. The decimal-point switch functions the same as before.

DC AND AC CURRENT MEASURING CIRCUIT

Figure 17 shows the circuitry for measuring DC or AC current.

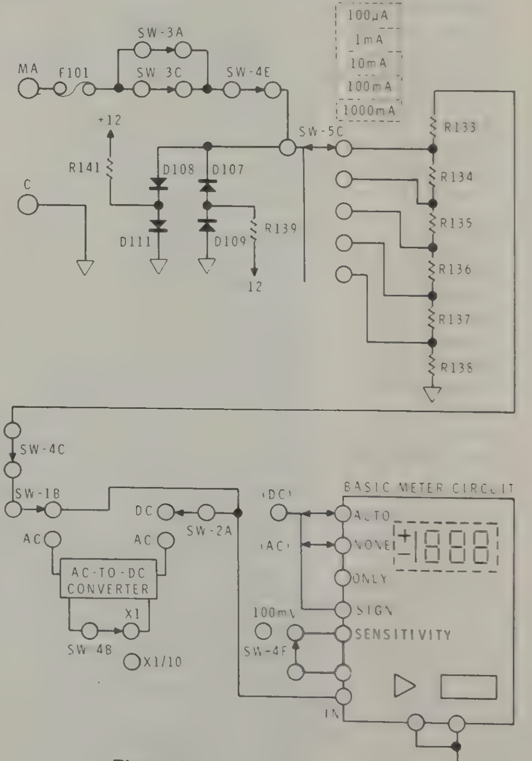


Figure 17

On the 100 µA range, the input current applied to the mA input flows through F101, SW3A and SW3C, SW4E, and SW5C; then through R134, R135, R136, R137 and R138, and returns to the C (common) input. On this range, the total resistance of the sensing resistors is 1000 Ω. When 100 µA (0.1 mA) flows through these resistors, there is a voltage drop of 0.1 volt. This voltage is coupled through R133 (which serves as overload protection), and then through SW4C and SW1B to the input of the basic meter circuit. SW4F selects the 100 millivolts sensitivity position for both DC and AC currents, and the decimal point is also switched as required.

For DC measurements, the sign switch is in the "AUTO" position. For AC measurements it is in the "NONE" position, while SW1B and SW2A switch in the AC-to-DC Converter.

Diodes D107 through D111, and resistors R139 and R141 form overload protection for the current-sensing resistors. Normally, the common connection of D107 and D108 is less than 0.2 volts DC (0.28 volts peak AC). The anode of D107 and the cathode of D108 are held at -0.7 volts and +0.7 volts respectively since D109 and D111 are forward-biased by R139 and R141. These voltages cause D107 and D108 to be normally reverse-biased, presenting a high impedance. If an overload occurs and the voltage drop exceeds 1.2 volts, either positive or negative, either D107 or D108 becomes forward-biased. Since the series impedance is low, a high current will flow. When the current exceeds the rating of F101, the fuse will open and disconnect the input.

RESISTANCE MEASURING CIRCUIT

Resistance measurements are accomplished by passing a precision, constant current through the unknown resistance and then measuring the voltage produced. See Figure 18.

On the 100 Ω range, the precision 1 mA current flows from the ohmmeter current source through R124, D105, SW5D, SW4D, SW3D, SW1C, F102, and Rx to C (common) as shown in Figure 18. The voltage generated across Rx is coupled through R123, SW5F, SW5E, SW4A, and SW1B to the basic meter circuit. The Sensitivity switch (part of SW5G) is closed to the 100-millivolt position, and the sign switch is in the None position. On the 1 kΩ range, the Sensitivity switch opens to the 1.0-volt position. The 1.0-volt is produced by the 1 mA of current flowing in the full-scale 1000 Ω.

On the 10 kΩ ranges, the precision current is 100 µA. On the 100 kΩ and the 1000 kΩ ranges the current is 1 µA.

Diode D105 protects the precision current source from any high positive voltage applied to the input. For negative overvoltages, diodes D105 and D106 are forward-biased and cause F102 to open. R124 limits current through the diodes for any transient negative voltages.

OHMMETER CURRENT SOURCE

The ohmmeter current source works in a slightly different manner from the ±I REF circuits.

In the 100 Ω position, the emitter of Q201A is biased by D201 while R401 and R402 determine the current through Q201B. This current source, 1 mA, is the same for both the 100 Ω and 1 kΩ positions while the basic meter circuit changes sensitivity for the 100 mV and 1.0 V produced.

On the 10 kΩ position, R402 and R404 set this current source at 100 µA.

On the 100 kΩ and 1 MΩ positions, due to the extremely low current of 1 µA, the circuit is controlled by fixed resistor R201, returning to a variable source (R202 and R203). This allows a wide, yet stable, adjustment range.

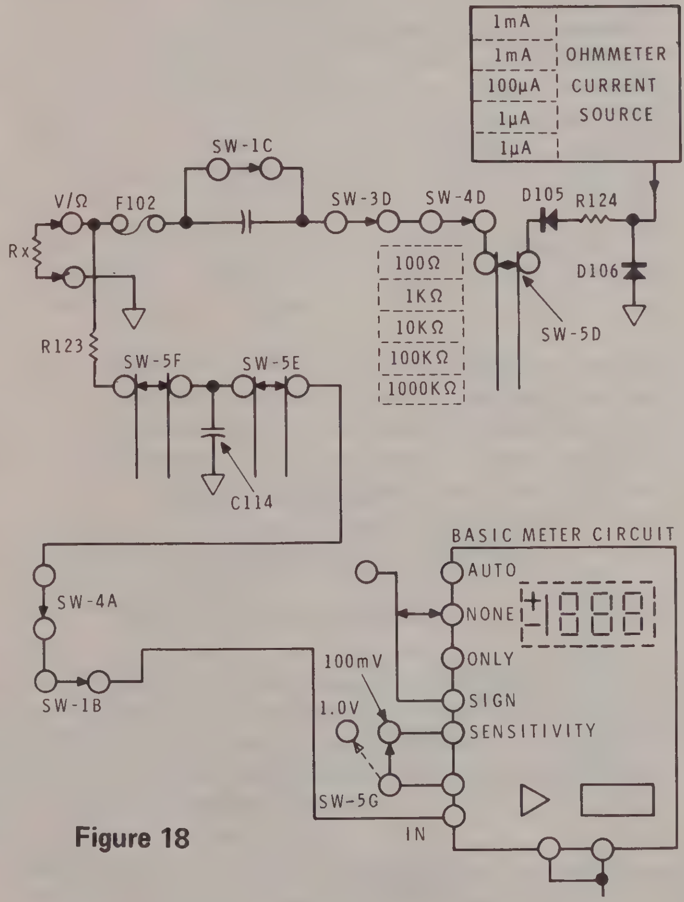


Figure 18

BATTERY TEST CIRCUIT

The Multimeter also provides circuitry for measuring its own battery voltage as shown in Figure 19.

E1 is connected through SW5H and SW5F to the resistive voltage divider of R125 through R128. The voltage at R127, typically .052 volts, is coupled through SW5E, SW4A, and SW1B to the basic meter circuit. The Sensitivity switch is closed to the 100-millivolts position and the sign switch is in the "– only" position. Since the input voltage is positive, no sign is displayed.

This also functions as a general display test by defeating the latch circuitry in the counters. This action causes a "blur" in all segments as the count accumulates. The "blur" is switched on by the positive constant-current source output of IC201. The blur occurs during the time the integrator is being discharged to the Zero level. The duty cycle and external transfer functions are changed at this time as described earlier. During the time just after the Zero level is reached, the output of IC201 switches off and causes the display to show a steady reading of the measured voltage.

This "steady blur" display occurs at about a 5 per second rate, as a reminder that the meter is not displaying an input measurement.

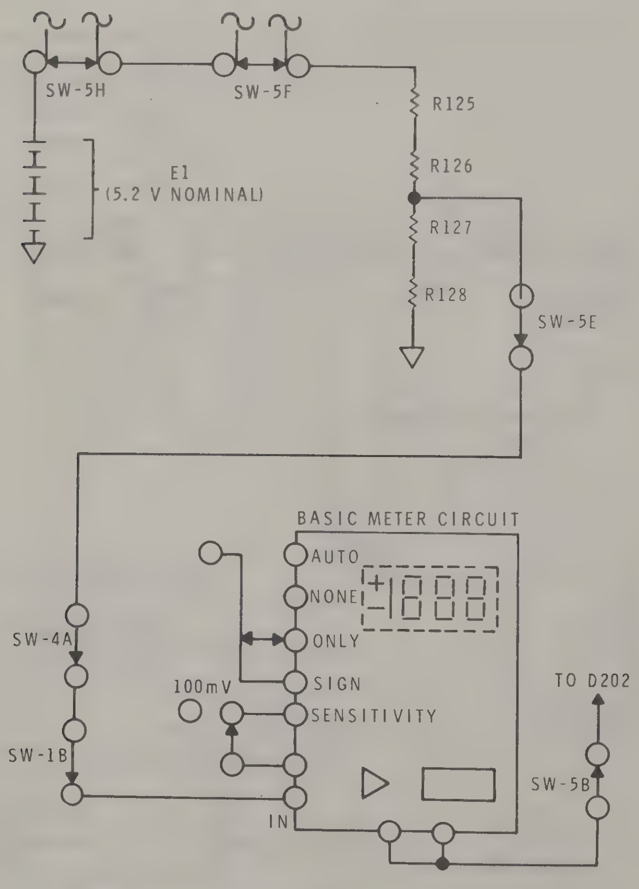


Figure 19

AC-to-DC CONVERTER

The AC-to-DC Converter Circuit is shown in Figure 20 (fold-out from Page 122). The circuit is basically a high input-impedance buffer which drives a dual-gain, operational amplifier connected as a precision rectifier.

Assume that SW4B is closed, which makes the resistance between Q102 and C101 approximately 10 kΩ. The AC signal, coupled through C113 of the input circuit, modulates the gate voltage of Q101. The voltage between the gate and the source of Q101 is held at about 3 volts. Q102 maintains this voltage by controlling the drain current of Q101. Together, they form a low output impedance driving circuit which fully couples the gate voltage variations to R105.

IC101 is connected as an inverting amplifier, so the direction of its output variations are opposite to the input variations. During the positive portion, the negative output voltage of IC101 is coupled through C107, D103, and R114 to point "Z" as shown in Figure 20. When the amplitude of the voltage at point Z is equal to the amplitude of the input at R105, the voltage division between R105 and R113 cancel to zero at R106. If the voltage at R106 does not cancel to zero, the large gain of IC101 increases or decreases the voltage at point Z until the proper level is reached. During negative portions of the input, the voltage output from IC101 goes positive. This couples through C107, D104, and R115 to point Z. So, the voltage variations at point Z are equal in amplitude to the voltage at R105.

When SW4B is open, the total of R104 and R105 (100 kΩ) requires a lower voltage at point Z to cancel the voltage at R106 to zero. This is exactly 1/10 of the previous output voltage. So, the "gain" of the circuit is either "times 1" or "times 1/10."

C107 causes the output to D103 and D104 to be an AC voltage. The positive output peaks, coupled through D104, charge C111 through R118. R119 and C112 provide further filtering. The voltage on C112 is coupled to SW2A through R122. R122 and R121 provide the proper DC source resistance to eliminate any DC shift at the integrator input of the basic meter circuit due to input bias current. This output voltage at C112 is proportional to the average AC voltage.

R108, C103, and R107 provide a DC feedback around IC101, which maintains the no-signal (quiescent) output voltage of IC101 at near zero. C102, C104, C105, and C106 provide high-frequency compensation to smooth and extend the frequency response of the circuit.

R116 and R117 calibrate the circuit by adjusting the voltage produced at point Z by current flow from R114 and R115. C108 and R109 provide noise filtering for the positive supply of the operational amplifier. R111, R112, and C109 provide equal filtering for the negative supply. D101, D102, and R101 protect Q101 from overload inputs.

POWER SUPPLIES

Power from the battery is converted to the various required supply voltages by the DC-to-DC voltage converter.

Voltage from the battery is coupled through SW5H to the L201, C221 filter circuit and to the emitters of Q231 and Q232. When power is applied, both transistor base-circuits try to turn on through their respective resistor networks. C222 slows the turn-on of Q231 just enough so that Q232 draws appreciable collector current through its winding first. The increase in voltage at Q232's collector increases its winding current, which magnetically induces a negative voltage at the collector of Q231. This negative voltage is then coupled through C223, R297, and R298 and turns Q232 on further, which increases its collector voltage even more. This action continues until Q232 is saturated, which applies full battery voltage to the transformer winding.

After a time, the current through Q232's winding stops changing, and the induced voltage at the collector of Q231 begins to drop to zero. This voltage is coupled through C223, R297, and R298, and starts to turn Q232 off. As Q232 turns off, the magnetic coupling changes direction and starts to turn Q231 on. The same regenerative action as before causes this to occur and eventually saturates Q231.

These current changes induce voltages at the secondary windings. The secondary voltage which produces the +170-volt supply is rectified by D206 to D209 and filtered by C225, R302, and C226. Positive variations at the anode of D206 cause C229 to charge through D215. When the voltage at D206 goes to zero, the point between C229 and D215 goes negative, which causes D215 to be reversed-biased. This action causes D216 to be forward-biased and transfers a charge to C231 to produce the low power, -170-volt supply.

On the other secondary winding, the series-connected capacitors, C227 and C228, are charged to the peak secondary voltage by D211 to D214. This voltage is applied to the current regulating circuit (Q233, Q234) and zener diodes D217 and D218. The DC ground reference at the center (and the center of C227 and C228) produce +12-volt and -12-volt supplies with regulated current through each zener. Resistor R304 senses this current and, if the voltage drop across it gets too high, Q234 begins to saturate. But since this turns Q233 off by diverting its base current, the current through R304 decreases; and is therefore regulated. C232 and C233 filter out any noise in the voltage supplies.

The base-emitter junction of Q229 is forward-biased when the battery polarity is correct, and the transistor collector-emitter junction is saturated. This low voltage drop applies almost the full battery voltage to the R292 and C217 to C219 filter network, and produces the +5-volt source.

REFERENCE AND CALIBRATION CIRCUITS

Diode D217 and three resistors; R305, R306, and R307; are provided as a measured set of parts. These parts are tested and the voltages at the 1.9 V TP and + TP junctions are accurately measured. The voltage measurements are supplied with the parts for use in calibration. Resistors R308, R309, and R311, and diode D218 are also supplied as a measured set. Only the -TP reference number is required from this set.

R293 to R296 are measured resistors, supplied with measurement numbers, to use when you calibrate the ohmmeter current sources.

D205, R288, and R289 provide an AC half-sine wave from the secondary winding of the battery charging transformer (T1). The center of R289 is adjusted to display a convenient number using the DC volts function. Since there is a mathematical relationship between what the Multimeter displays on "AC Volts" from this same half sine wave voltage, the AC function can also be calibrated.

BATTERY CHARGING CIRCUIT

AC voltage is coupled through F1 and the 120/240 volt wiring to charger transformer T1. The transformer's low voltage output is current limited by R1 and rectified by D112 to provide charging to E1 in current pulses. This occurs whether SW5H is on or off.

Any AC radiated voltages ("pick-up"), on the Multimeter chassis, are shunted to earth ground by capacitor C1.

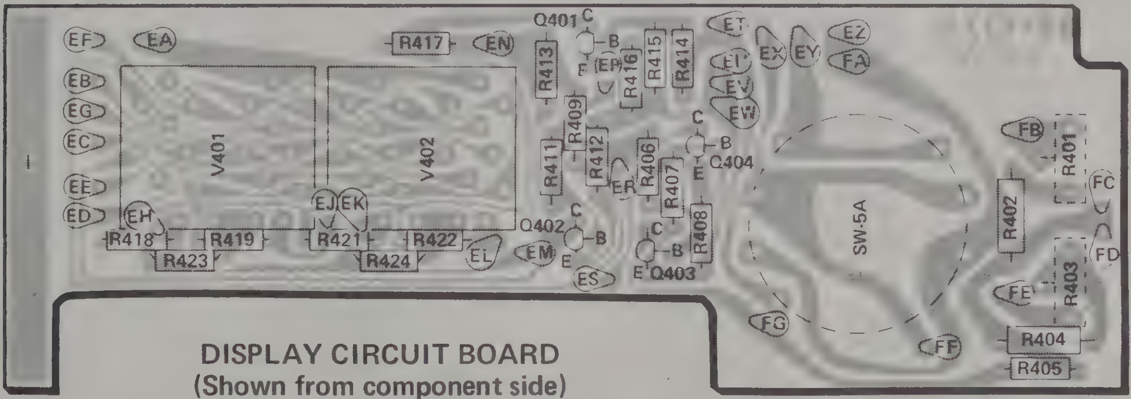
CIRCUIT BOARD X-RAY VIEWS

NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

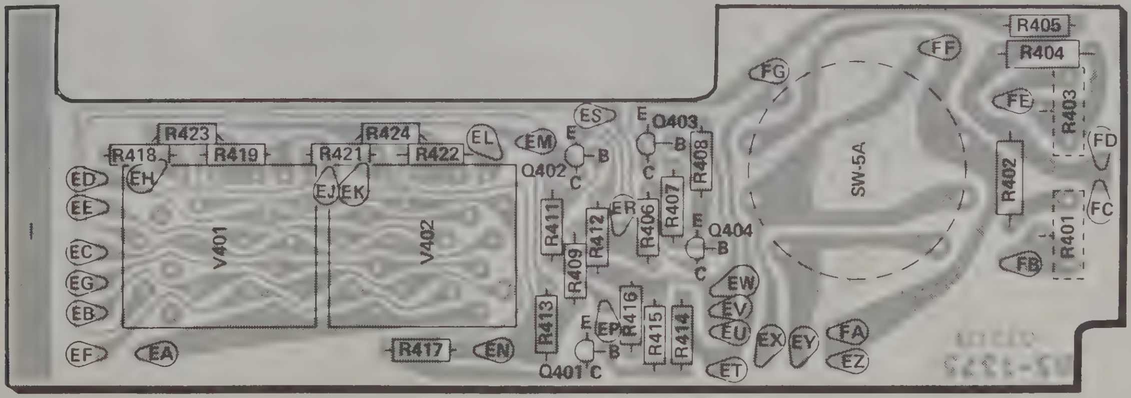
A. Find the circuit component number (R5, C3, etc.) on the "X-Ray View."

B. Locate this same number in the "Circuit Component Number" column of the "Parts List."

C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.

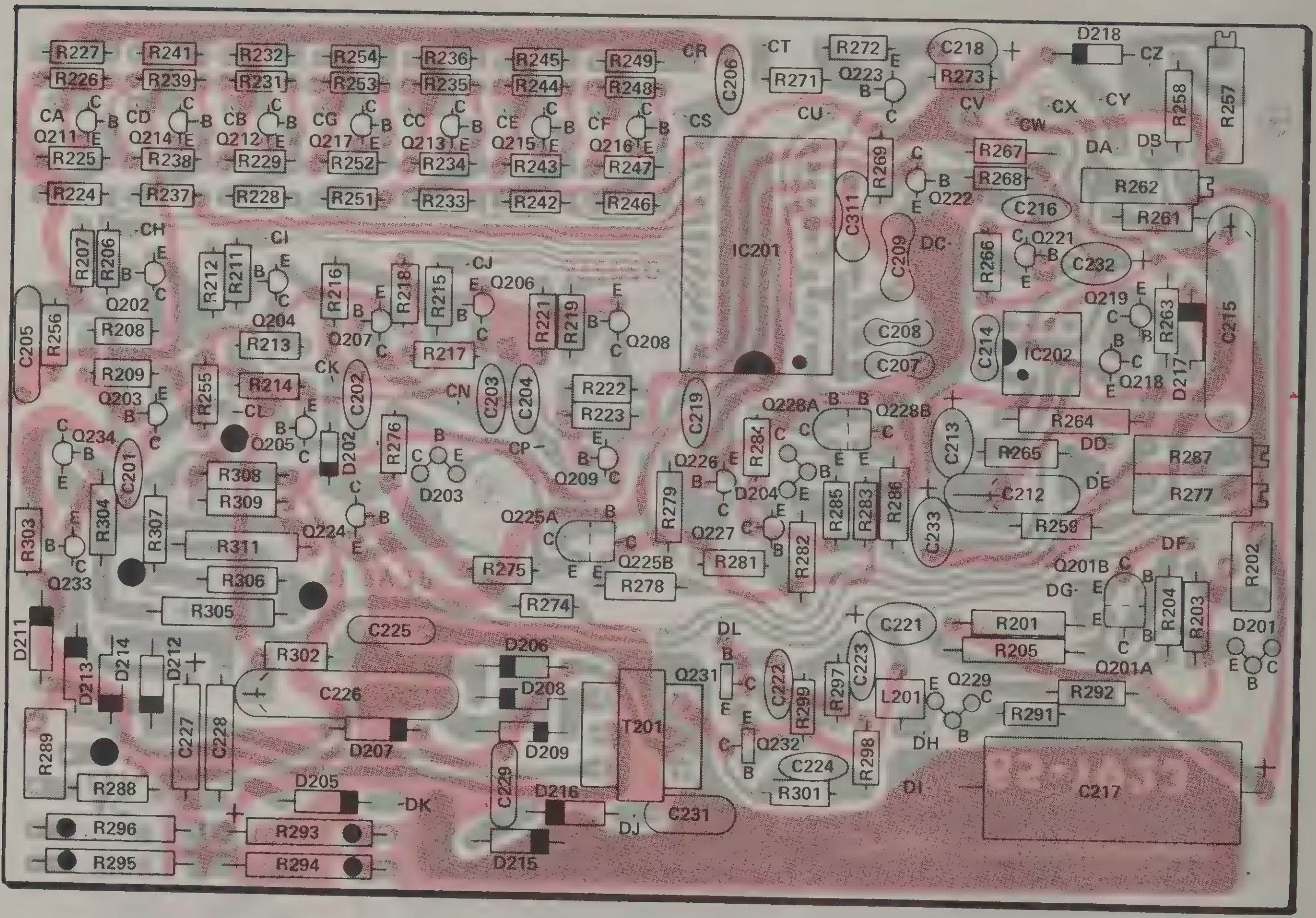


DISPLAY CIRCUIT BOARD
(Shown from component side)

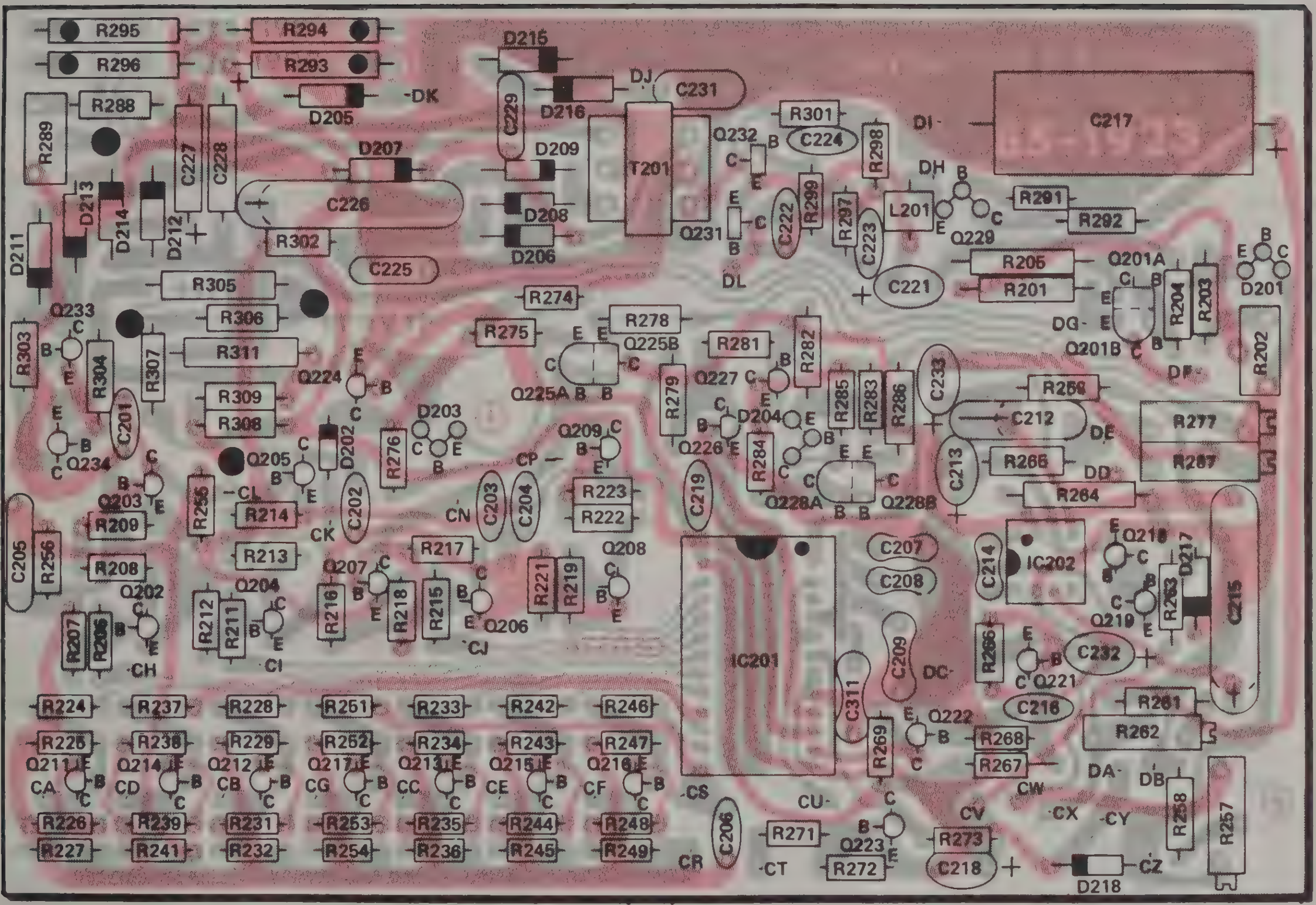


DISPLAY CIRCUIT BOARD
(Shown from foil side)

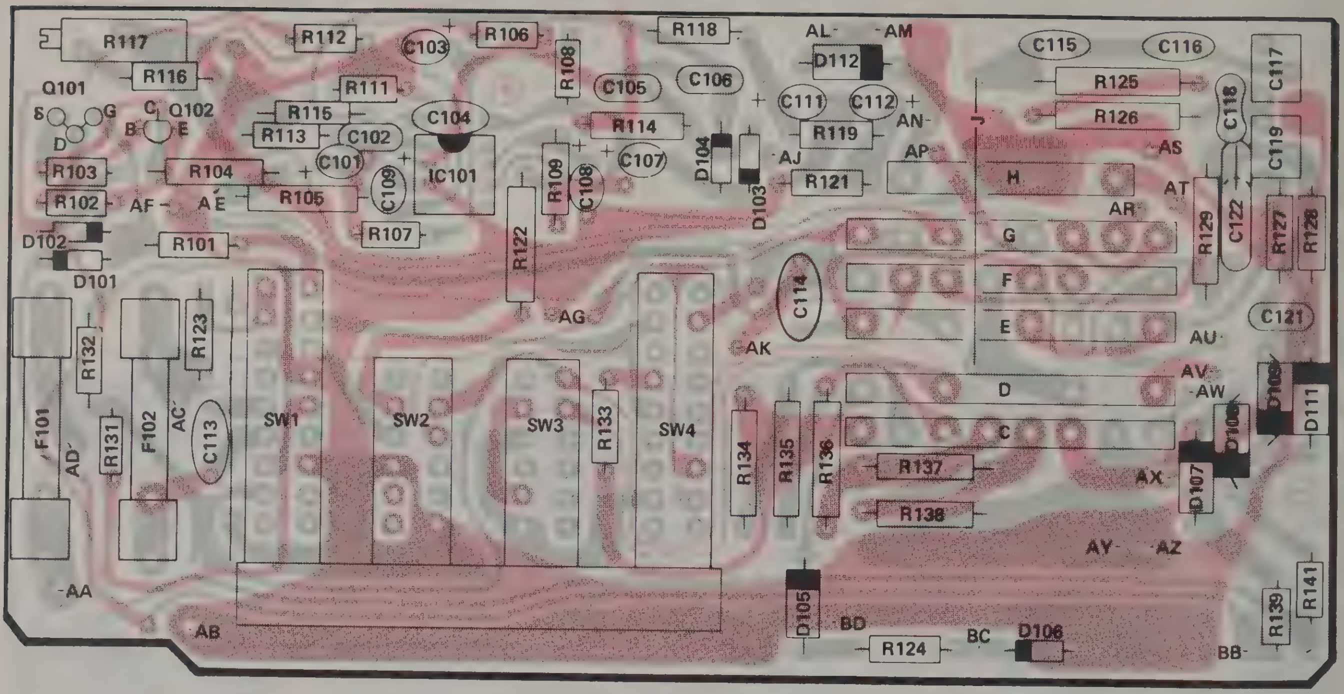
LOGIC CIRCUIT BOARD
(Shown from component side)



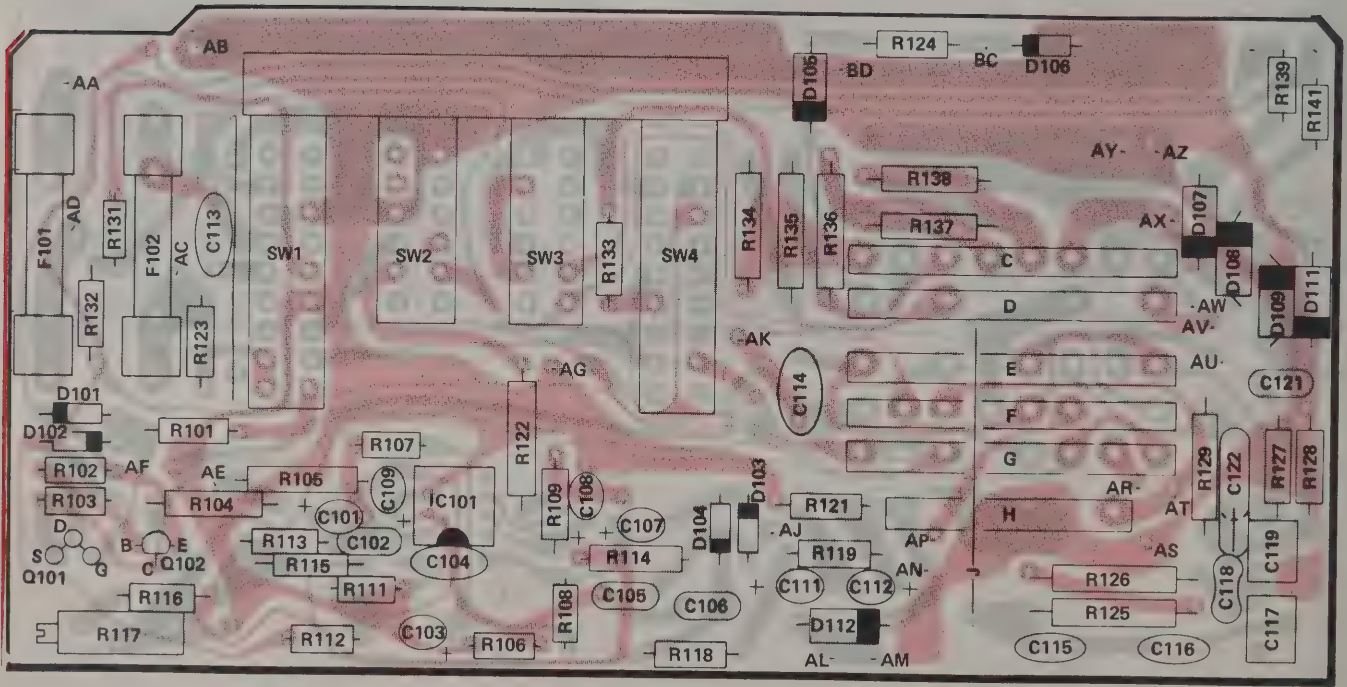
LOGIC CIRCUIT BOARD
(Shown from foil side)



INPUT CIRCUIT BOARD
(Shown from component side)



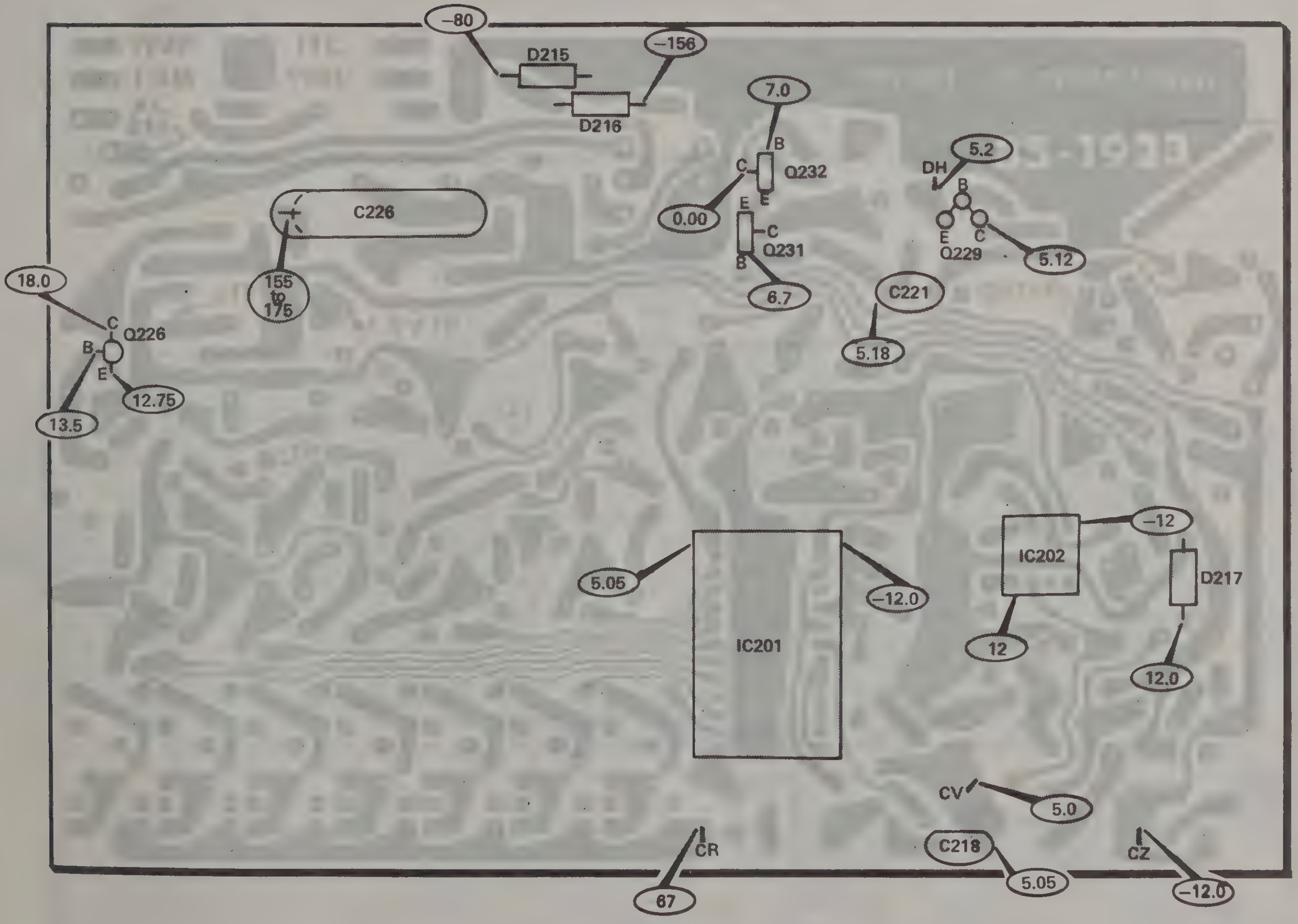
INPUT CIRCUIT BOARD
(Shown from foil side)



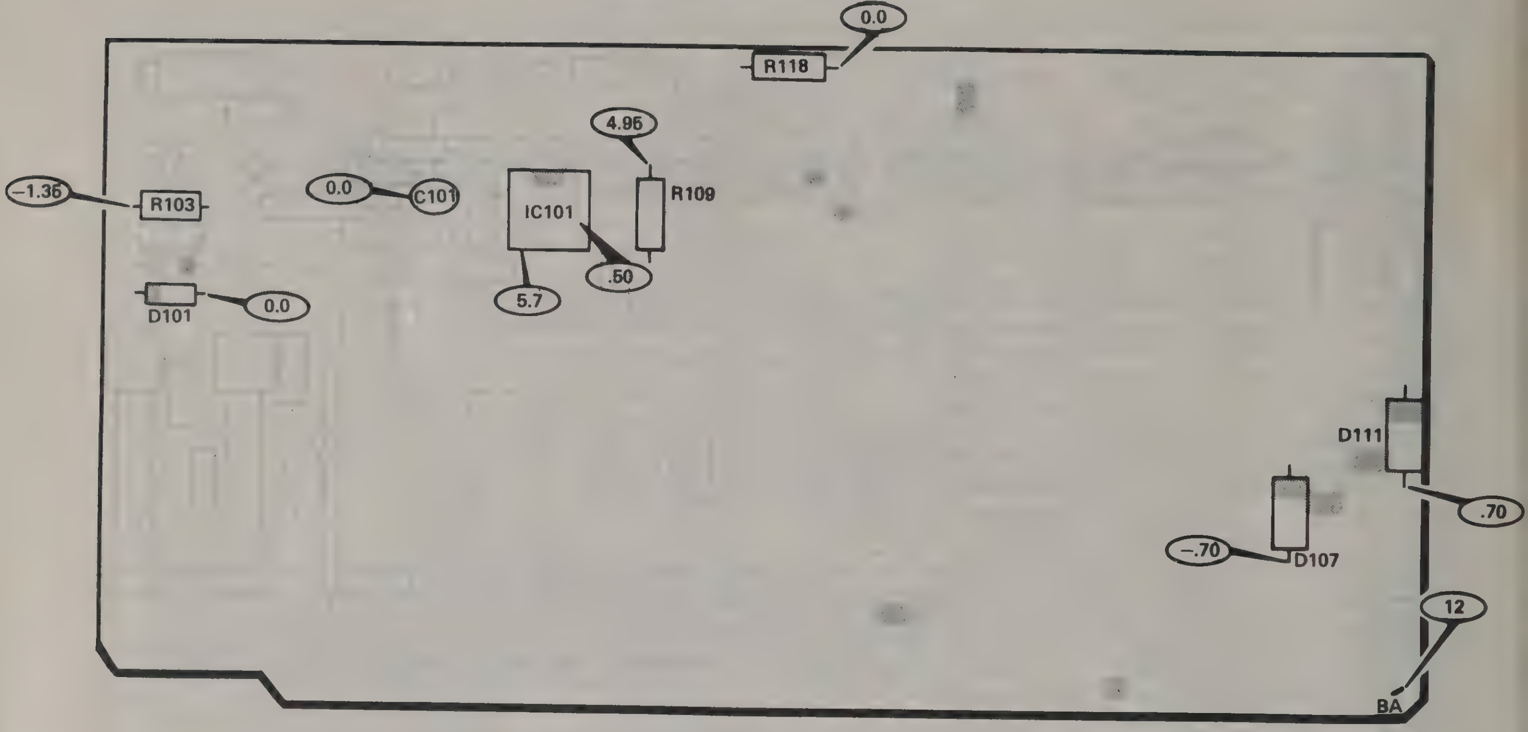
CIRCUIT BOARD VOLTAGE CHARTS

The DC voltage measurements in this section were taken with a high-impedance input voltmeter from the point indicated to circuit board ground with the DC/Ω and V/Ω switches pushed in. Voltages may vary ±20%.

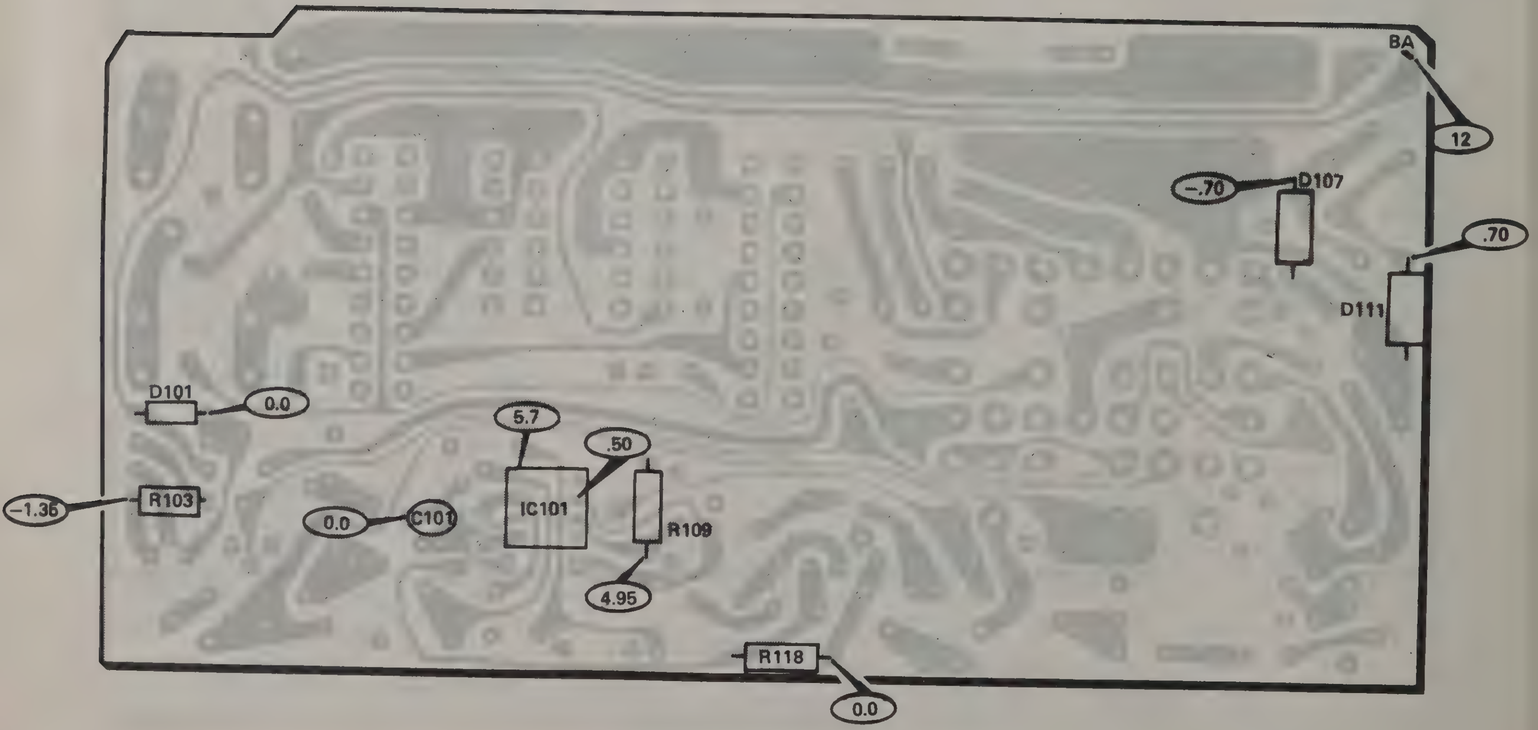
LOGIC CIRCUIT BOARD
(shown from foil side)



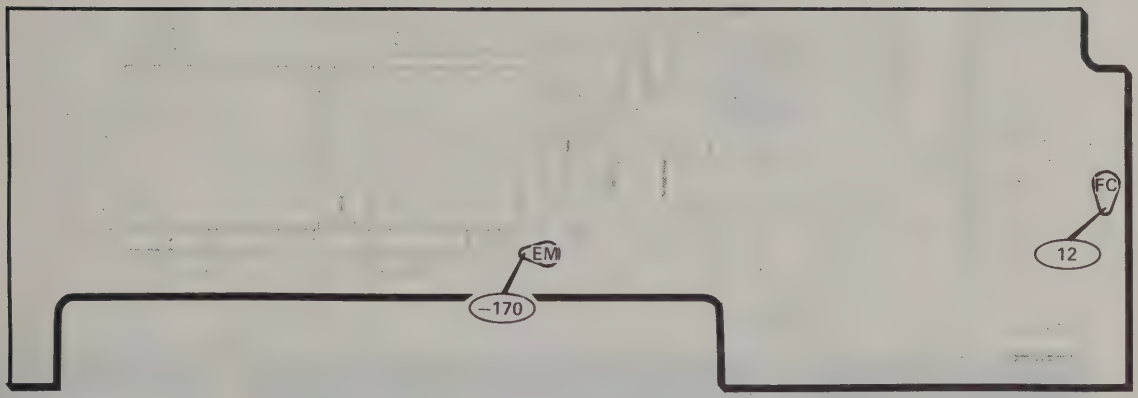
INPUT CIRCUIT BOARD
(Shown from component side)



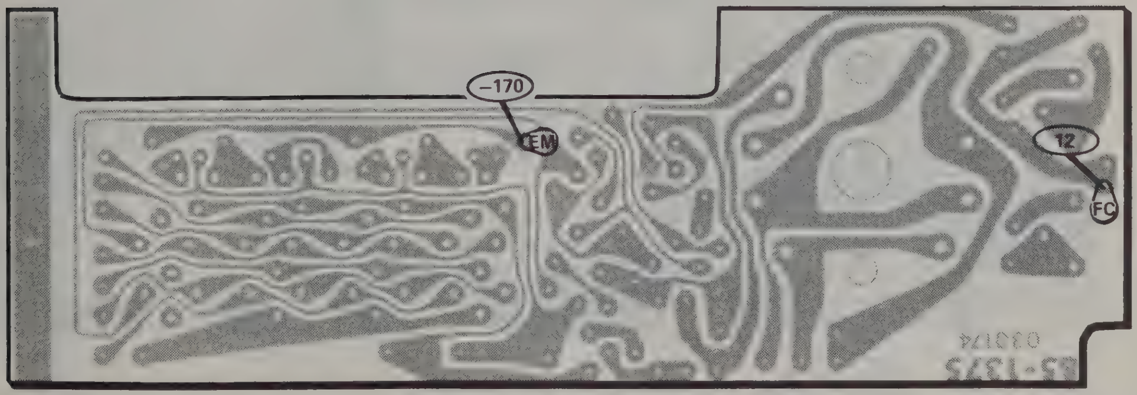
INPUT CIRCUIT BOARD
(Shown from foil side)



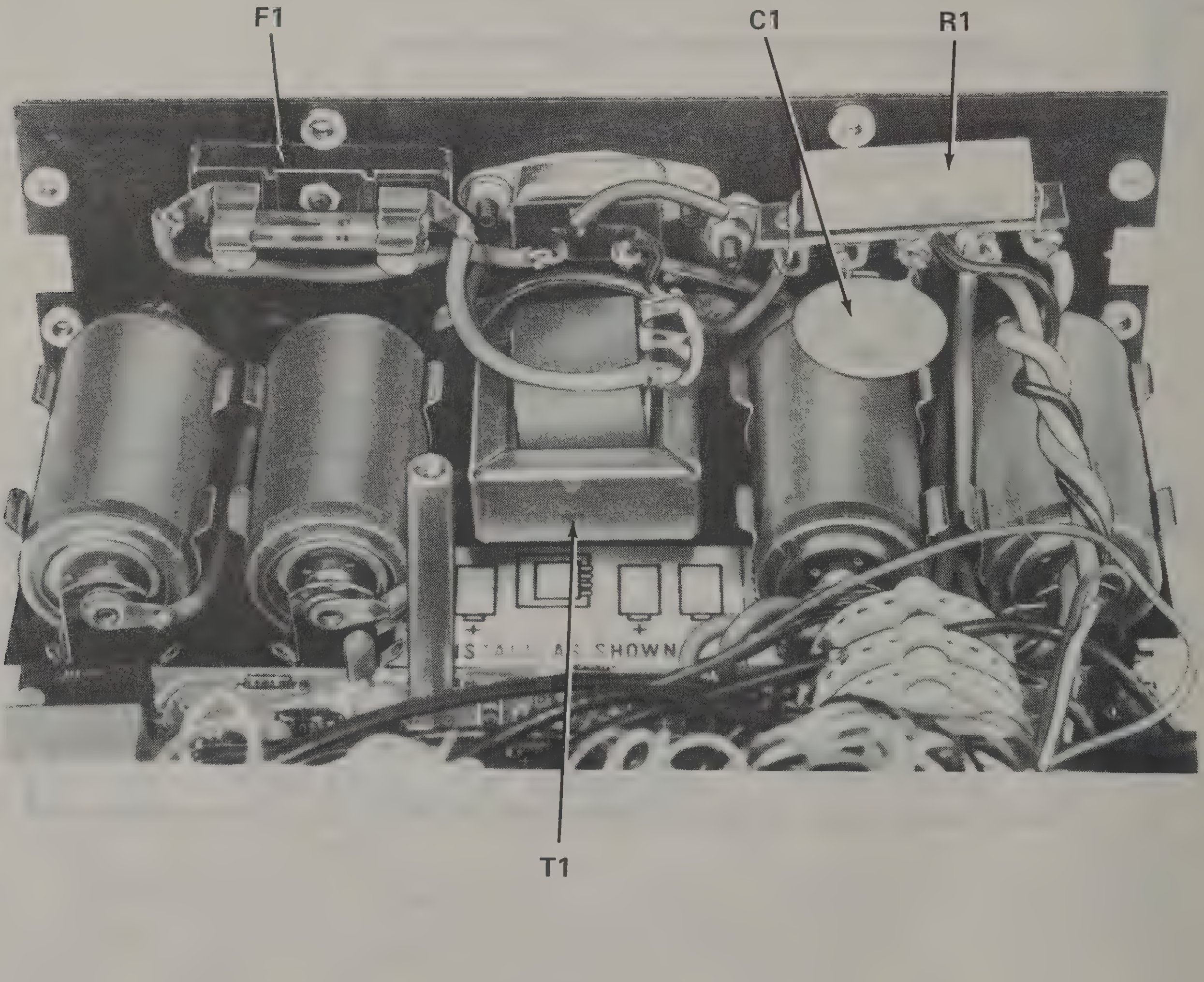
DISPLAY CIRCUIT BOARD
(Shown from component side)



DISPLAY CIRCUIT BOARD
(Shown from foil side)

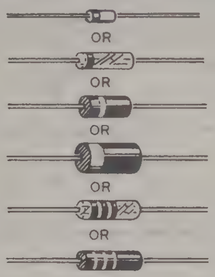


CHASSIS PHOTOGRAPHS

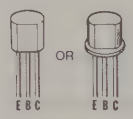
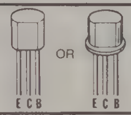
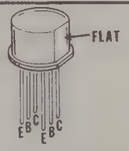
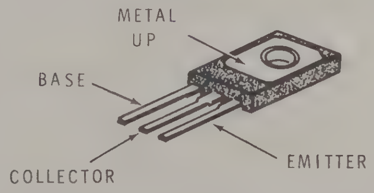


SEMICONDUCTOR IDENTIFICATION CHARTS

LOGIC CIRCUIT BOARD

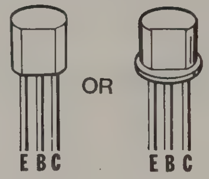
COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	BASE DIAGRAM
D202	56-56	1N4149	NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES. 
D206, D207, D208, D209 D215, D216	57-27	1N2071	
D205, D211, D212, D213, D214	57-65	1N4002	
D201, D203, D204	417-242	SELECTED ZENER	OPTIONAL

TRANSISTORS

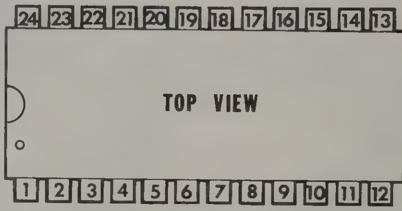
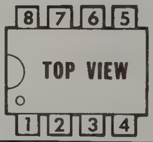
Q229	417-234	2N3638A	
Q202, Q204, Q206, Q208, Q211, Q212, Q213, Q214, Q215, Q216, Q217	417-294	MPSA42	
Q203, Q205, Q207, Q209	417-295	MPSL51	
Q221, Q222, Q223, Q224, Q226, Q233, Q234	417-801	MPSA20	
Q218, Q219,	417-67	2N2712	
Q227	417-201	X29A829	
Q231, Q232	417-849	TZ553	
Q201, Q225	417-261	TD401	
Q228	417-191	TD101	
Q231,Q232	417-819	MJE171	

DISPLAY CIRCUIT BOARD

TRANSISTORS

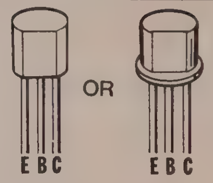
COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	BASE DIAGRAM
Q401, Q402, Q404	417-294	MPSA42	
Q403	417-801	MPSA20	

INTEGRATED CIRCUITS

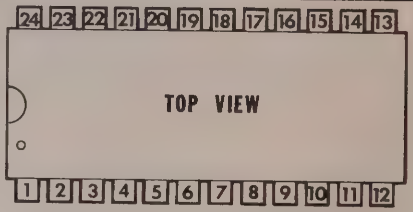
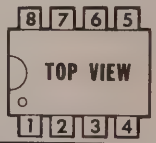
IC201	443-626	MK6013	 24 23 22 21 20 19 18 17 16 15 14 13 TOP VIEW 1 2 3 4 5 6 7 8 9 10 11 12
IC202	442-66	LM308AN	

DISPLAY CIRCUIT BOARD

TRANSISTORS

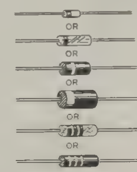
COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	BASE DIAGRAM
Q401, Q402, Q404	417-294	MPSA42	
Q403	417-801	MPSA20	

INTEGRATED CIRCUITS

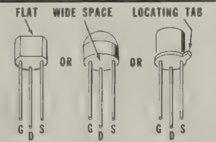
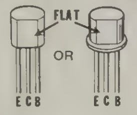
IC201	443-626	MK6013	 24 23 22 21 20 19 18 17 16 15 14 13 TOP VIEW 1 2 3 4 5 6 7 8 9 10 11 12
IC202	442-66	LM308AN	

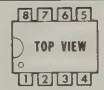
INPUT CIRCUIT BOARD

DIODES

D103, D104	56-89	GD510	NOTE HEATH PART NUMBERS ARE STAMPED ON MOST DIODES. 
D101, D102, D106	56-93	FD333	
D105	57-27	1N2071	
D109, D111	57-42	3A1	
D112	57-65	1N4002	
D107, D108	57-[illegible]	Selected Silicon Rectifier	

TRANSISTORS

Q101	417-140	2N4304	 FLAT WIDE SPACE LOCATING TAB OR OR G D S G D S G D S
Q102	417-201	X29A829	

IC101	442-39	LM301AN	

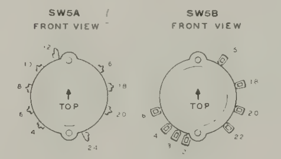
SCHEMATIC OF THE HEATHKIT® IM-2202 PORTABLE DIGITAL MULTIMETER

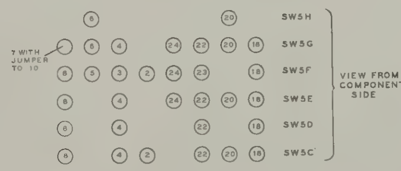
NOTES:

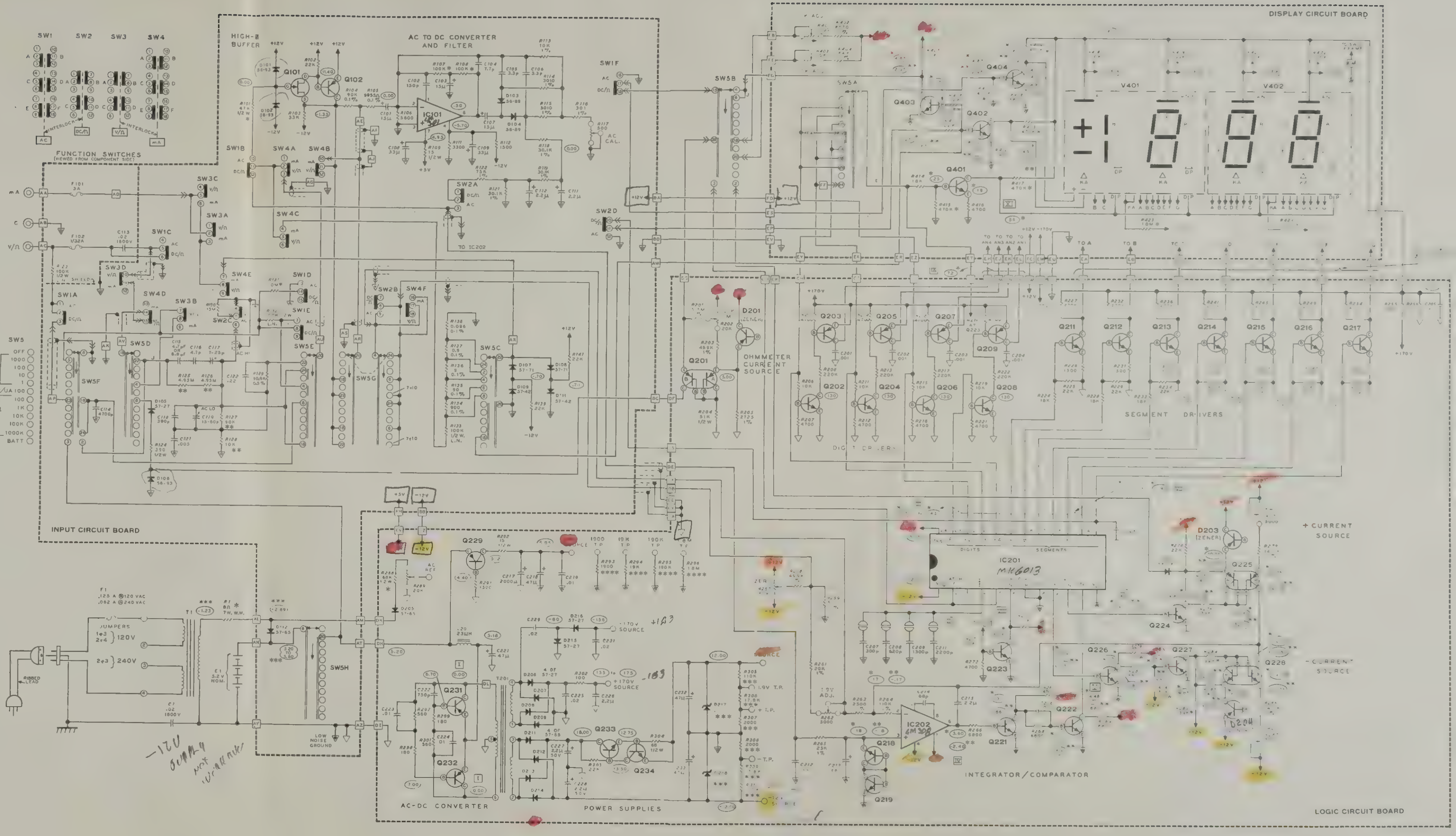
1. RESISTORS ARE 1/4 WATT, 5% UNLESS OTHERWISE INDICATED.
2. RESISTORS WITH AN ASTERISK (*) ARE 10%.
3. ALL 5% AND 10% RESISTORS ARE CARBON COMPOSITION EXCEPT R1.
4. ALL CAPACITORS SHOWN IN DECIMAL ARE µF.
5. ** INDICATES PARTS FROM 9-60.
6. *** INDICATES PARTS FROM 100-1631.
7. **** INDICATES PARTS FROM 100-1643.
8. LN INDICATES LOW-NOISE RESISTORS.
9. ⏚ INDICATES LOW NOISE GROUND.
10. ⏬ INDICATES WIRE CONNECTIONS TO THE LOOP END OF ONE OF THE SOLDER LUGS OF SW1 TO SW4.
11. ⊐ INDICATES A LETTERED HOLE ON A CIRCUIT BOARD.
12. WW INDICATES WIREWOUND.
13. SW5 SHOWN IN "OFF" POSITION.

THE FOLLOWING DC VOLTAGES WERE MEASURED USING A HIGH IMPEDANCE (10MΩ OR GREATER) VOLTMETER FROM THE MEASUREMENT POINT TO THE (COMMON) INPUT JACK. VOLTAGES MAY VARY ± 20%.

- ☐ — WAVEFORMS USING BATT POSITION: SEE PAGE 107.
- ○ — DC VOLTAGES FOR ANY INPUT IN 100mV POSITION.
- ○* — DC VOLTAGES IN 100mV POSITION USING +TP AS INPUT; VOLTAGES WILL BE DIFFERENT FOR DIFFERENT INPUTS.
- ○** — DC VOLTAGES IN 100mV POSITION USING -TP AS INPUT; VOLTAGES WILL BE DIFFERENT FOR DIFFERENT INPUTS.
- ○*** — DC VOLTAGES DURING BATTERY CHARGING. EXPOSED LINE VOLTAGE IS PRESENT -- USE EXTREME CAUTION.







-12V supply not available

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, $3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $__________
- If you prefer COD shipment, check the COD box and mail this form. COD ☐

NAME ______________________________

ADDRESS ______________________________

CITY ______________________________

STATE ____________________ ZIP __________

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # ______________ Invoice # ______________

Date Purchased ______________ Location Purchased ______________

LIST **HEATH** PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE
TOTAL FOR PARTS			
HANDLING AND SHIPPING			
MICHIGAN RESIDENTS ADD 4% TAX			
TOTAL AMOUNT OF ORDER			

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUT ALONG DOTTED LINE

FOR PARTS REQUESTS ONLY

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- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

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CITY ______________________________

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ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUSTOMER SERVICE

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

TECHNICAL CONSULTATION

Need help with your kit? — Self-Service? — Construction? — Operation? — Call or write for assistance. you'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment. Do not include the kit Manual.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

HEATH
Schlumberger

HEATH COMPANY • BENTON HARBOR, MICHIGAN

THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

LITHO IN U.S.A.